WATER AND RELATED LAND RESOURCES
SAN JUAN RIVER BASIN
ARIZONA, COLORADO
NEW MEXICO AND UTAH

A Report Based on a Cooperative Study by

COLORADO WATER CONSERVATION BOARD

and

UNITED STATES DEPARTMENT OF AGRICULTURE

Prepared by

Soil Conservation Service - Economic Research Service - Forest Service

USDA-SCS-PORTLAND, OREG. 1974

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San Juan River near Four Corners

SCS PHOTO

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SOIL CONSERVATION SERVICE - ECONOMIC RESEARCH SERVICE - FOREST SERVICE

Denver, Colorado - June 1974

WATER SUPPLY (1914-65)

ON-SITE DEPLETIONS & OUTFLOW FOR 1965

(THOUSANDS OF ACRE-FEET)

Water Yield	2158.5
Import	+100.7
Water Supply	2259.2
On-Site Depletions	365.0
Export	2.5
River Depletion	367.5
Outflow at Bluff, Utah	1891.7

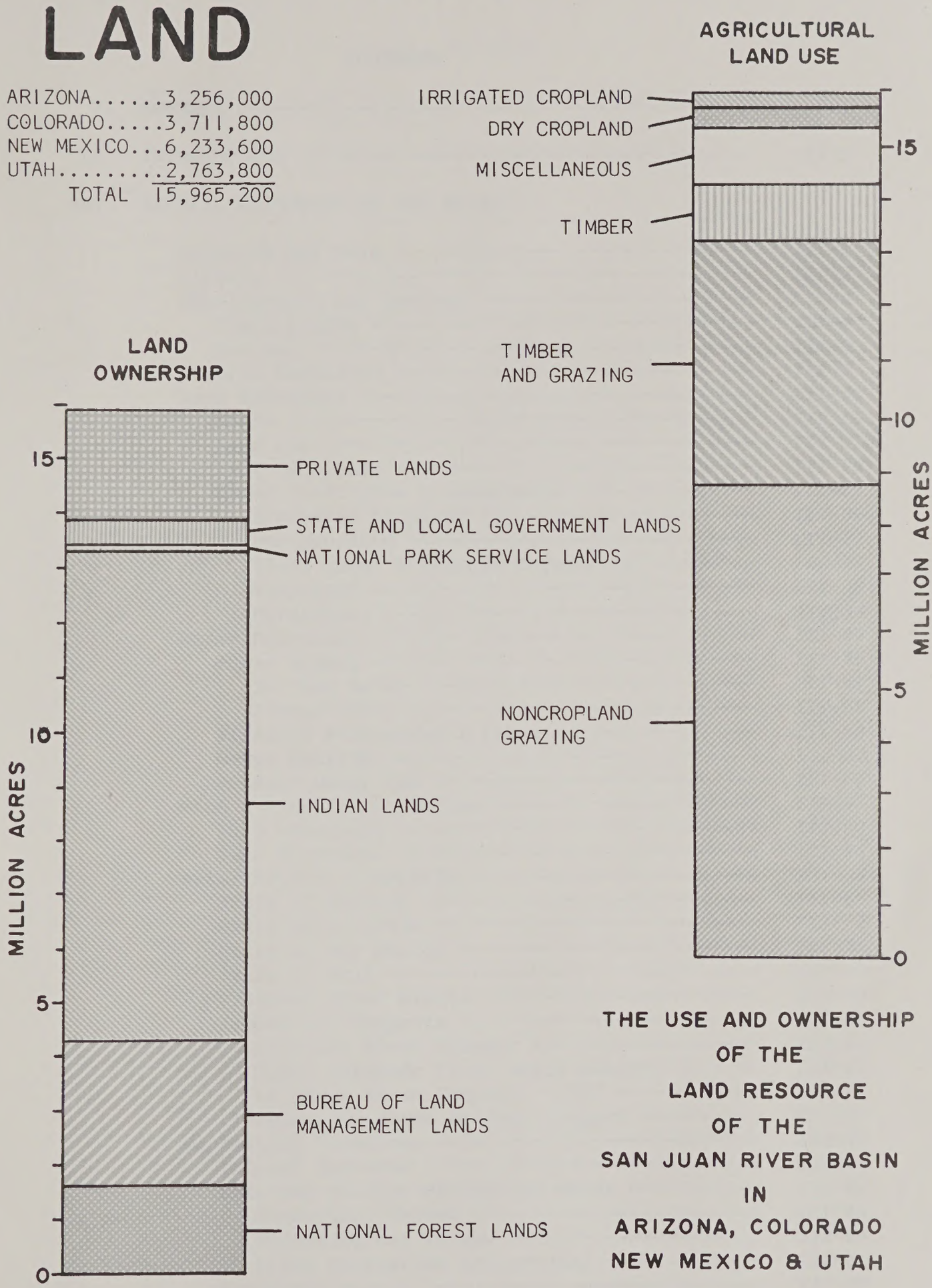
WATER

THE WATER RESOURCE OF THE SAN JUAN RIVER BASIN IN ARIZONA, COLORADO, NEW MEXICO & UTAH

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1974

LAND

ARIZONA.....3,256,000
COLORADO.....3,711,800
NEW MEXICO...6,233,600
UTAH.....2,763,800
TOTAL 15,965,200



THE USE AND OWNERSHIP
OF THE
LAND RESOURCE
OF THE
SAN JUAN RIVER BASIN
IN
ARIZONA, COLORADO
NEW MEXICO & UTAH

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1974

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WATER AND RELATED LAND RESOURCES

SAN JUAN RIVER BASIN IN ARIZONA, COLORADO, NEW MEXICO AND UTAH

I. SUMMARY

The broad objective of the study area is the collection and development of information on water and related land resource use and management, with particular regard to multiple use. This information will provide a basis for effective coordination of USDA programs for watershed protection, flood prevention, agricultural water management, recreation, fish and wildlife development, municipal and industrial water development, and associated national forest administration, with the related activities of local, state, and other federal agencies.

This report presents information concerning water and related land resources of the San Juan River Basin located in the "Four Corners" area of Arizona, Colorado, New Mexico and Utah. The study area includes those portions of these states within the hydrologic boundaries of the San Juan River down to its confluence with the Colorado River and Lake Powell.

The San Juan River Basin drains an area including 15,965,200 acres. About 39 percent of the drainage area is in New Mexico; 23 percent in Colorado; 20 percent in Arizona and 17 percent in Utah. The San Juan River is the second largest tributary to the Colorado River. Its source is on the Continental Divide in southern Colorado and it flows approximately 350 river miles westerly to its confluence with the Colorado at a point about 80 miles upstream from Lee Ferry.

The Basin is about 240 miles in length from east to west, and nearly 150 miles from north to south. Elevations vary from about 3,200 feet above sea level at the confluence with the Colorado River to about 14,000 feet on the crests of mountain peaks in the San Juan range. Precipitation varies from more than 60 inches annually in small areas along the high peaks, to less than 10 inches in extensive areas of the lower part of the basin. Water yields range from more than 30 inches annually in parts of the basin, to less than one-tenth inch in others.

Agricultural problems are mostly related to low farm incomes and underemployment of resources stemming from the small size, low productivity, relative isolation, lack of processing facilities, and distance from markets of the farms and ranches.

Parts of the population exist in a chronically depressed economic condition. There is an urgent need for development of the basin's resource potentials. There are opportunities for increasing the

areas of land under irrigation, increasing mining exploration, developing known mineral resources, expanding the utilization and processing of forest products, and expansion of recreation developments. Broadening of the economic base is urgently needed to provide employment opportunities in new and expanded industries and associated service enterprises that would result from these developments.

The basin has numerous land use and management problems. Gully and streambank erosion, streambed aggradation and seeping of bottomlands, problem soils, sediment production, and excessive runoff are widespread. Phreatophyte invasion of irrigated areas is common. This accentuates problems associated with inadequate lateseason irrigation water supplies. Mine and concentrator tailings, radioactive uranium mill wastes, irrigation return flows, diffuse salt areas, and sediment production from eroding lands constitute hazards to water quality.

The only railroad in the basin is the narrow gauge branch of the Denver and Rio Grande Western. This line provides only limited freight capacity. The Silverton branch has been developed into a very successful tourist attraction. Paving of roads and highways in recent years has improved farm-to-market transportation facilities and relieved somewhat the relative isolation of the area. The main line of the Santa Fe Railraod passes near the southern border of the basin and is readily accessible by highway; however, the distance from this rail source to the populated part of the basin makes rail transportation both slow and expensive. Connections to Denver and other principal market areas are poor. Consequently, most of the transportation requirements have to be met by highway facilities. Frontier Air Lines provides scheduled air service at three points within the Basin.

Overgrazing by domestic livestock has resulted in gullying and soil loss on some areas within the basin and has contributed to a severe deterioration of vegetative cover over large areas. Good range management could improve production of range forage, contribute to improved water yield and reduce erosion and sediment production.

Timber and other forest products are important to the economy of the basin. There are a number of operating sawmills, a paneling plant, a match-stick factory, and a new spruce plywood mill in production employing over a 1,000 people. The total value of wood products produced in 1968 was in excess of $16 million.

The higher mountains forming the rim of the basin constitute a popular recreation area. The basin has several developed recreation areas including national forest lands, national parks and monuments, historical and scenic locations, and private recreation sites and developments. The tourist and recreation industry is a very important element in the economy contributing more than $18 million in 1965. The basin has remarkable recreation attractions, such as fishing

U. S. DEPARTMENT OF AGRICULTURE

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LOCATION MAP

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

JULY 1972

10 0 10 20 MILES

SCALE 1:1,150,000

M7-S-22573 -N

along sparkling streams, boating, camping, rock hounding, big game hunting, skiing, and sightseeing. All of these recreation activities are in demand and there is potential for developing additional natural historic and scenic resources.

Livestock and livestock product sales were $19.5 million in 1969. Nearly 95 percent of irrigated cropland harvested and 17 percent of dry cropland harvested was used to produce livestock related crops in 1965.

The Cortez-Dove Creek, Colorado and Monticello, Utah areas are dry bean production centers with over 120,000 acres of dry cropland annually planted to dry bean production. There are about 367,200 acres in dryland crop production with most near the above towns.

Average annual undepleted water supply for the 1914-1965 period was 2,158,500 acre-feet; average annual depletion was 367,500 acre-feet, and the average annual discharge at Bluff, Utah was 1,891,700 acre-feet (WATER, Frontispiece 1). The major use of the water within the basin was for irrigation with 69.7 percent of the total depletion.

The 1965 irrigated acreage was 256,800 with a projected level of irrigation development of an additional 206,400 acres, mainly for livestock feed and forage to meet anticipated red meat demand. Irrigable land and water resources are adequate, under compact limitations, to meet proposed resource developments outlined in this report, including potential municipal and industrial requirements.

About all of the additional irrigated land required are contained within the Bureau of Reclamation's proposed Dolores and Animas-La Plata projects currently under advanced planning and the Navajo Irrigation Project currently under construction.

Seventeen smaller agricultural water management projects feasible under the Soil Conservation Service's Public Law 566 program or Resource Conservation and Development Program (RC&D) could have water savings and crop production impacts on about 95,000 acres presently being irrigated.

Program coordination is necessary to assure that proposed project and resource development opportunities complement each other and provide for coordinated development of resources of the basin. Program coordination can be accomplished through USDA Committees for Rural Development and the Four Corners Regional Commission.

II. INTRODUCTION

The Colorado Water Conservation Board is conducting a broad water resources study of tributary watersheds of the Colorado River Basin in Colorado. These studies are being made to provide a basis for coordinating further planning for development and use of water and related land resources. The Colorado Water Conservation Board initiated a study of the water and land resources of the San Juan River Basin in Colorado. Since the drainage area of the basin extends into Arizona, Colorado, New Mexico and Utah, and problems relating to development and use of water and related land resources are distributed throughout the basin without respect to state boundaries, the Colorado Water Conservation Board invited the state agencies with similar responsibilities to participate in the study.

As a consequence of their interests in the basin, the New Mexico State Engineer, Utah's Department of Natural Resources, and Arizona's State Land Department have joined with Colorado in the conduct of this survey to the end that mutual interests may be recognized and opportunities for development appraised. Within this framework, the survey will be basin-wide in the collection, analysis, and presentation of information while recognizing separate interests and objectives of the four states in their parts of the drainage basin.

The participating states need information for solving water and related land resources problems and to study relationships between future developments. Information from the U.S. Department of Agriculture will fill the *gap* that exists between farm-by-farm conservation operations information and the larger project-type information now available, or to be made available, by the Corps of Engineers, Bureau of Reclamation, and other federal agencies.

Participation of the U.S. Department of Agriculture was authorized under provisions of Section 6, Watershed Protection and Flood Prevention Act (Public Law 566), 83rd Congress, as amended, and supplemented. This authorizes the Department to cooperate with other federal, state and local agencies in making investigations and surveys of watersheds or rivers as a basis for development of coordinated programs.

The U.S. Department of Agriculture's participation was in accordance with the Memorandum of Understanding among the Economic Research Service, U.S. Forest Service, and the Soil Conservation Service, dated February 2, 1956, and revised April 15, 1968.

Survey work by the U.S. Department of Agriculture was carried out by technicians of the Soil Conservation Service, Forest Service, and Economic Research Service under the direction of a USDA Field Advisory Committee, Colorado Rivers, composed of representatives of the above agencies.

Existing information from reports of previous studies, as well as available information from various federal, state, and private sources, was used to the extent it was suitable. Included were the *1969 Conservation Needs Inventories* and the *Upper Colorado Region Comprehensive Framework Study* which was completed in June 1971. Other recent studies include the *Water Conservation and Salvage Study* and the *Erosion and Sedimentation Study* conducted by the Soil Conservation Service.

The survey will assist the Department of Agriculture in making the most effective use of their limited resources in the administration of the Public Law 566 watershed program and the Resource Conservation and Development program. It will serve also as a guide in coordinating related water and land resources development programs and projects of other local, state and federal agencies.

III. NATURAL RESOURCES OF THE BASIN [1/]

LOCATION AND SIZE

The San Juan River Basin is located in the *Four Corners* area of Arizona, Colorado, New Mexico and Utah. It includes 8 percent of New Mexico, 5.5 percent of Colorado, 5.1 percent of Utah, and 4.5 percent of Arizona. The basin extends approximately 250 miles east and west, and 160 miles north and south. It is entirely within the Upper Colorado Region and drains an area of 24,945 square miles (15,965,200 acres) or about one-fourth of this region.

The New Mexico portion comprises 39 percent of the basin and includes nearly all of San Juan County and parts of Rio Arriba, Sandoval, and McKinley counties.

Slightly more than 23 percent of the basin is within Colorado. Included are La Plata, most of Archuleta, Montezuma and San Juan, and parts of Dolores, Hinsdale and Mineral counties. Very small areas of San Miguel, Rio Grande, and Conejos counties are also included in the basin.

Arizona has a little over 20 percent of the area of the basin which consists of parts of Apache, Navajo and Coconino counties. The remaining portion of the basin (about 17 percent) is in San Juan county, Utah. The northern and northwestern boundary of the basin is defined by the Gunnison, Dolores, and Colorado River divides. The eastern and southeastern boundary follows the Continental Divide. The southern and southwestern boundary is the divide of the East and West Puercos and the Little Colorado Rivers. The extreme western boundary is the divide of the Colorado River.

1/ *Modified from the Upper Colorado Region Comprehensive Framework Study, Appendix VI.*

Four Corners National Monument - The only point in the United States common to four state corners

SCS PHOTO

CLIMATE

The climate of the basin varies from alpine in the high mountains to desert at the low elevations. The higher part of the basin is in Colorado with more than 30 peaks of the San Juan mountains ranging from 12,000 to over 14,000 feet elevation. The highest point is Windom Peak in Colorado which rises to 14,084 feet. The lowest elevation of the basin is at the confluence of the Colorado and San Juan Rivers - 3,600 feet above sea level. The areas above 10,000 feet elevation have higher precipitation, lower winter temperatures and cooler summer temperatures. The areas under 7,000 feet have relatively mild winters, hot summers, and low precipitation.

The basin is in the zone of westerly winds. As wet air masses move inland and are lifted at the high mountains of the San Juan and the Continental Divide, they release large quantities of moisture in the form of snow in the winter months and cool rains in the summer months. The precipitation increases as the air mass rises higher and is further cooled. Intermediate elevations have moderate climate and rainfall. Pagosa Springs, Colorado at an elevation of 7,200 feet, has a mean annual precipitation of about 20 inches, (Average Annual Precipitation Map follows page III-2). Mexican Hat, Utah at an elevation of 4,250 feet, has a mean annual precipitation of only slightly more than 6 inches. The frost-free period at Pagosa Springs averages under 80 days with a mean high temperature of 64°F. and a mean low of just under 20°F. The

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LOCATION MAP

1931-60 Average Annual Precipitation, In Inches

- 4 to 8 Inches
- 8 to 12 Inches
- 12 to 16 Inches
- 16 to 20 Inches
- 20 to 25 Inches
- 25 to 30 Inches
- 30 to 40 Inches
- 40 to 50 Inches
- Over 50 Inches
- ▲ Active Stream Gage
- ● Precipitation Station

AVERAGE ANNUAL PRECIPITATION
(BASE PERIOD 1931-1960)

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

OCTOBER 1972

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SCALE 1:1,150,000

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frost-free period for Mexican Hat is over 190 days. The mean high temperature is over 82°F. and the mean low is just under the frost threshold at 31.9°F. January is the coldest month of the year in the basin, and July is the hottest.

Artic fronts from Canada seldom have sufficient depth to breakover the Continental Divide. This spares the basin from the frigid blasts which occur in the high plains and front range areas east of the Divide. Air masses moving north from the Gulf of Mexico are generally diverted to the east by the high mountains of the Continental Divide and do not have a significant influence on the climate of the basin.

Occasionally in the summer, the westerly winds over the Pacific Ocean will shift to the southwest and advance to the basin from the south across the Gulf of California, over the deserts of Mexico, Arizona, and New Mexico bringing hot dry air and a *rain shadow* effect to the San Juan Basin.

The greatest precipitation in the agricultural areas of the basin occurs during the months of July through October. During these four months the basin receives nearly half of its average annual precipitation. The balance is distributed fairly uniformly by months except for June which is the driest month of the year.

The snowpack which accumulates in the high mountain areas during the winter months has reached measured depth of nearly 12 feet with water equivalent of almost 5 feet. Melting of these snowpacks causes high spring flood flows and results in sustained summer streamflows. Tributaries entering the San Juan River from the south in Arizona and New Mexico produce intermittent streamflow, mostly from high intensity, short duration, convective-type summer showers. Precipitation from widespread low intensity storms is rapidly absorbed in the desert areas and produces little runoff. The desert soils are highly susceptible to erosion because of sparse vegetative cover and low organic content. Sediment yields from these areas are high, and when runoff does occur, the desert tributaries contribute heavily to the downstream sediment load.

The wide range of climatic conditions in the basin has resulted in a diversified agriculture ranging from alfalfa, grass hay, and pasture at locations of short growing seasons and cooler temperatures, to corn, small grain, dry beans, truck gardens, orchards, and melons in the areas of milder climates.

The tourist and recreation industry have year-around benefits from the climate variations. The cool and refreshing atmosphere of the mountain parks, lakes, and streams offer much sought relief from sweltering desert and city life in the summer. High snowpacked

slopes with bright, clear days and warm sunshine attracts winter sports enthusiasts throughout the winter months. Other winter vacationers are attracted by mild winter days in the sunshine and warmth of the desert.

PHYSIOGRAPHY AND GEOLOGY

Physiography

Most of the San Juan River Basin lies within the northern part of the Navajo section of the Colorado Plateaus physiographic province, an area of plateaus underlain by relatively horizontal sedimentary rock layers which form mesas, buttes, cuesta ridges, and rock terraces separated by broad, open valleys and occasional canyons. An area in the northwestern part of the basin lies within the Canyon Lands section of the Colorado Plateaus province, and narrow areas along the northeastern margin of the basin are occupied by the San Juan mountains portion of the Southern Rocky Mountains physiographic province. Elevations vary from about 3,600 feet at Lake Powell along the lower reaches of the San Juan River to 14,084 feet on Windom Mountain in the Needle Mountains area in the central portion of the San Juan Mountains northeast of Durango, Colorado.

The San Juan Mountains are a well-defined area of rugged mountains rising abruptly from the mesa and foothill surfaces of the adjoining Colorado Plateaus province and containing numerous peaks over 13,000 feet. They consist largely of volcanic rocks in more or less horizontal layers overlying older sedimentary rocks. Most of the area has been glaciated, and such typical features as knife-edge ridges, cirques, and rock streams are common.

The most rugged part of the San Juan Mountains is known as the Needle Mountains, and here the mountains consist mainly of older, more resistant crystalline rocks such as granites, gneisses, and schists. At the southwestern end of the San Juan Mountains are two smaller ranges - the Rico Mountains and the La Plata Mountains. Both are domed uplifts of sedimentary rocks intruded by igneous rocks. Both groups have many peaks more than 12,000 feet.

The main part of the San Juan River Basin, lying within the Colorado Plateaus province, is an area of diverse topography containing numerous mesas and plateaus underlain by resistant rock layers, extensive areas of plains and broad valleys with gentle slopes cut in softer rocks, gently sloping ridges, hogback ridges, high dome mountains, some rough badlands, and a few deep, narrow canyons. The most predominant features of this area are the scattered mountains which, in most cases, were formed by the doming of sedimentary rock layers by igneous intrusions. These include the Ute Mountains in

southwestern Colorado, the Abajo Mountains in Utah, Navajo Mountain along the boundary between Utah and Arizona, the Carrizo Mountains in northeastern Arizona, and the Chuska Mountains in Arizona and New Mexico. All of these mountains contain local areas of steep ridges and narrow valleys and all contain peaks rising to above 9,000 feet.

A plains topography interspersed with gently sloping ridges and scattered badlands predominates over large areas in the southern parts of the basin in much of the drainage basins of Chinle Wash in Arizona, and the Chaco River in New Mexico. These areas are underlain mainly by relatively soft sedimentary strata. Elevations average between 5,000 and 6,000 feet.

Sedimentary Deposits - New Mexico
near Four Corners SCS PHOTO

In other parts of the basin, mainly the northern and eastern portions, the presence of more resistant sedimentary rock layers has resulted in a more rugged topography containing low mesas and narrow canyons formed mostly in horizontal rock layers but in places,

having steeply dipping hogback ridges. Elevations in these areas average between 6,000 and 7,000 feet.

Among the more prominent plateaus in the basin are Mesa Verde near the southwestern corner of Colorado, and the Defiance Plateau lying between the Chinle Valley and the Chuska Mountains. Elevations in the higher portion of both of these plateau areas average between 7,000 and 8,000 feet.

Mesa Verde is a high, deeply dissected plateau that slopes gently southward. The streams that drain the area have cut deep canyons, many of which reach nearly to the north rim of the plateau and divide it into numerous narrow mesa fingers that trend southward. Large alcoves in the sandstone cliffs at the heads and along the sides of the canyons are the sites of many ruins of ancient cliff dwellings.

The Defiance Plateau is also a deeply dissected tableland dominated by the narrow mesas and deep canyons of the Canyon de Chelly area. The trend of these canyons is mainly to the west, and they range to over 1,000 feet in depth.

Geology

Rocks ranging in age from Precambrian through Quaternary are exposed in the San Juan River Basin (Generalized Bedrock Geology Map follows page III-6). They consist of crystalline rocks of Precambrian Age, volcanic rocks of Tertiary Age, and a thich sequence of sedimentary rocks of Paleozoic, Mesozoic, and Cenozoic Ages. Distribution of these rocks is controlled by four major structural features: the San Juan structural basin, the Needle Mountains upwarp, the Monument upwarp, and the Defiance upwarp. The older rocks are generally exposed in the upwarped areas where the younger rocks have been removed by erosion, while the younger rocks occur mainly in the central portions of the San Juan structural basin.

The San Juan structural basin occupies a large part of the eastern half of the San Juan River Basin. It is a broad structural depression which was also the original basin of deposition for early Cenozoic sediments. On the north, it is flanked by the Needle Mountains upwarp; on the northwest, it is flanked by the Monument upwarp; and on the southwest, by the Defiance upwarp.

LOCATION MAP

CENOZOIC

- Tv — Tertiary Volcanics
- Tm — Miocene
- Tpe — Paleocene and Eocene

MESOZOIC

- Kuu — Upper Cretaceous (upper part)
- Kul — Upper Cretaceous (lower part)
- KJ℟ — Cretaceous, Jurassic, Triassic
- ℟ — Triassic (Chinle Formation)

PALEOZOIC

- Pz

PRECAMBRIAN

- P€

- Metal Mines
- Coal Deposits (Less than 3,000 feet depth)
- Oil Field
- Gas Field

BEDROCK GEOLOGY MAP

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

AUGUST 1970

10 0 10 20
SCALE IN MILES

4073-1

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, COLORADO 1970

GPO 830-594

Needle Mountains south of Silverton, Colorado
SCS PHOTO

The oldest part of the San Juan River Basin, geologically, is in the Needle Mountains area in Colorado where crystalline rocks of Precambrian Age are exposed. These rocks consist of a complex series of schists, gneisses, and granites. Rocks of Paleozoic Age crop out on the southern and western flanks of the Needle Mountains and in the adjacent Rico and La Plata Mountains in Colorado. These rocks include quartzites, limestones, and shales in the lower part overlain by red arkosic sandstones and conglomerates together with beds of red mudstone and siltstone in the upper part. In the Monument upwarp area in Utah and Arizona, reddish sandstones and siltstones are exposed over extensive areas. Small outcrop areas of sandstone occur along the narrow canyons of the Canyon de Chelly area in Arizona.

Mesozoic rocks crop out extensively in many parts of the basin and consist of several thousand feet of alternating beds of sandstones, siltstones, and shales with the sandstones predominating. Important resources associated with these rocks include prominent coal beds

in the upper part of the section and numerous oil and gas fields located mainly across the central part of the basin in New Mexico, Colorado, and Utah. The outcrop area of shales of Mesozoic contains some of the most erodible soils and highest sediment producing areas in the basin.

Sedimentary rocks of early Cenozoic age consisting mainly of shales and sandstones occur through the center of the San Juan structural basin covering a large area in New Mexico and a smaller area in Colorado. Socialized badlands areas in the high erosion and sediment yield occur occasionally in the rocks of this age.

Volcanic rocks of middle and late Cenozoic age occur along the northeastern edges of the San Juan River Basin in Colorado and form most of the high peaks in the San Juan mountains. They include rocks of flow origin as well as a variety of rocks of pyroclastic origin, such as tuff, welded tuff, tuff agglomerate, and tuff breccia. Masses of intrusive igneous rocks form the cores of such mountain areas as the Ute Mountains, La Plata Mountains, and Rico Mountains in Colorado; the Carrizo Mountains in Arizona, and some of the more prominent peaks in the Chuska Mountains in New Mexico and Arizona.

Quaternary deposits ranging in age from Pleistocene to Recent (not shown on the Geology map) are widespread in the San Juan River Basin. Glacial moraines representing several intervals of glaciation are present along most of the major valleys in the San Juan Mountains and the La Plata Mountains in Colorado. Landslide deposits, rock glaciers, and talus deposits are also common in these mountains.

Several levels of mesa and terrace surfaces underlain by sandy and gravelly alluvial deposits occur along the larger stream valleys and bordering isolated mountain areas, such as the Ute Mountains in Colorado, the Carrizo Mountains in Arizona, and the Chuska Mountains in New Mexico. Deposits of windblown silt and sand occur on some of the more extensive mesa surfaces in Colorado, such as the Sage Plain in the Dove Creek-Cortez area and the Red Mesa and Florida Mesa areas south of Durango. Large areas of wind-deposited sand occur in the southeast corner of Utah, the northeast corner of Arizona, and along the west side of Chinle Wash in Arizona. Recent alluvium occurs in the flood plains of most smaller tributaries as well as along the larger streams.

MINERAL RESOURCES

Natural gas, crude oil, uranium, vanadium, zinc, lead, sand and gravel, and coal are the most important minerals being produced currently in the basin. Petroleum products including helium as well as natural gas and crude oil account for the largest percentage of this production.

Natural gas fields occupy extensive areas over much of the central portion of the San Juan structural basin in San Juan and Rio Arriba counties in New Mexico and La Plata County in Colorado. The total natural gas resources of the San Juan River Basin has been estimated at about 12 trillion cubic feet. The associated helium resource has been estimated at about 13 billion cubic feet.

Gas Plant near Bloomfield, New Mexico
SCS PHOTO

Production of crude oil is mainly from a series of fields lying along the southern and western margins of the San Juan structural basin in San Juan, Rio Arriba, and Sandoval counties in New Mexico and from several fields in the Aneth area in the southeastern part of San Juan County, Utah. There also are a few small fields in Montezuma, Archuleta and La Plata counties in Colorado. The total crude oil resource in the San Juan River Basin has been estimated at about 1 billion barrels.

Most of the production of uranium and associated vanadium ores has been from the Monticello district in eastern San Juan County, Utah, the Monument district in Arizona and Utah, and the Shiprock and Chuska districts at the western edge of San Juan County, New Mexico. The deposits occur mainly in the Morrison and Chinle formations.

Production of other metallic minerals including zinc, lead, copper, silver, and gold has been almost entirely from the San Juan Mountains in the Silverton area of San Juan County, Colorado.

Sand and gravel produced at pits throughout the basin area are used mainly for construction purposes such as aggregates for concrete, mortar and asphalt, and as road base material.

The coal resources of the basin are located mainly in the Mesa Verde group of Upper Cretaceous Age which is at or within 3,000 feet of the surface around the margins of the San Juan structural basin in New Mexico and Colorado. A total of 9,646 million tons of bituminous coal is estimated to have been originally present in the Colorado portion of the basin. In New Mexico 4,085 million tons of bituminous coal and 28,414 million tons of sub-bituminous coal are estimated to have been originally present. In Colorado and Utah, additional coal resources are present as thin beds in the Dakota Formation, but no firm estimates of the quantities present are available. At present coal production in the basin is relatively low. Other potentially valuable but as yet generally unevaluated mineral resources of the San Juan Basin include gypsum, salt (halite), and potash deposits. Some of the gypsum deposits lie at or near the ground surface, but the salt and potash deposits lie at depths of several hundred feet or more.

LAND RESOURCES

Soils

The General Soil Map locates soils with similar characteristics and suitability within the basin. (General Soils Map follows page III-10). Broad characteristics and relationships can then be used to interpret the potential of soils for agricultural, recreational, commercial, and industrial uses. Problems of erosion, sediment yield, land use, and future development are interrelated with soils and their distribution.

The General Soils Map was prepared by delineating 28 mapping units that differ from each other in the kinds of soil that are present. Soils in each mapping unit form patterns that are repeated from place-to-place. Mapping units were defined and described according to requirements imposed by the map scale and criteria from the Comprehensive System of Soil Classification adopted in January 1965. Soil mapping units were placed in six major groups for purposes of broad interpretation. Five of the groups are distinguished by their climates and one is set apart by the fact that it consists of land types and shallow soils. Acreage distribution of the soil mapping units and groups along with percent that each occupies is given in Table III-1. Dominant characteristics of each mapping unit are given in Table III-2.

LEGEND

I. SOILS OF WARM ARID TO DRY SEMIARID REGIONS

AREAS DOMINATED BY SOILS IN ALLUVIAL DEPOSITS

1 Deep soils on valley floodplains, fans, and terraces

2 Deep, loamy soils on uplands

AREAS DOMINATED BY SOILS IN WIND-DEPOSITED OR WIND-WORKED MATERIALS

3 Deep, sandy, reddish-brown colored soils

4 Deep, loamy, reddish-brown colored soils with horizons of lime accumulation

5 Deep, sandy and loamy, reddish-brown colored soils and rock outcrop

AREAS DOMINATED BY SOILS IN WIND-DEPOSITED MATERIALS AND RESIDUUM FROM SANDSTONE AND SHALE

6 Deep to shallow, loamy, reddish-brown colored soils

AREAS DOMINATED BY SOILS IN SANDY ALLUVIAL AND WIND-DEPOSITED MATERIALS

7 Deep, sandy, light-brown or light reddish-brown colored soils

AREAS DOMINATED BY SOILS OVER SHALE AND IN CLAYEY ALLUVIUM

8 Shallow, light-colored, upland soils, and deep alluvial soils

II. SOILS OF WARM SEMIARID TO DRY SUBHUMID REGIONS

AREAS DOMINATED BY SOILS IN WIND-DEPOSITED MATERIALS

9 Deep and moderately deep, dark reddish-brown and reddish-brown colored soils

10 Deep and moderately deep, dark reddish-brown and reddish-brown colored soils (low precipitation zone)

AREAS DOMINATED BY SOILS IN WIND-DEPOSITED MATERIALS AND OVER SANDSTONE

11 Deep, sandy, brown-colored soils and rock land

AREAS DOMINATED BY SOILS OVER SHALE AND IN CLAYEY ALLUVIUM

12 Deep and moderately deep, moderately dark-colored soils

13 Shallow to deep, light-colored soils

AREAS DOMINATED BY SOILS OVER SHALE AND SANDSTONE AND IN ALLUVIUM

14 Deep to shallow, light-colored soils

AREAS DOMINATED BY SOILS OVER SHALE AND SANDSTONE AND IN WIND-DEPOSITED MATERIALS

15 Shallow to deep, light-colored soils

AREAS DOMINATED BY SOILS IN GRAVELLY AND COBBLY OUTWASH

16 Deep and moderately deep, dark reddish-brown colored soils

AREAS DOMINATED BY SOILS IN RESIDUUM AND ALLUVIUM FROM SANDSTONE AND REDBEDS

17 Deep and moderately deep, loamy, dark reddish-brown and reddish-brown colored soils

III. SOILS OF WARM SUBHUMID MOUNTAIN REGIONS

AREAS DOMINATED BY SOILS OVER SHALE AND SANDSTONE

18 Moderately deep to shallow dark-colored soils

IV. SOILS OF COOL TO COLD SUBHUMID MOUNTAIN REGIONS

AREAS DOMINATED BY SOILS OVER SANDSTONE

19 Deep to shallow, loamy, dark-colored soils and rock land

20 Shallow, dark-colored soils

AREAS DOMINATED BY SOILS OVER SHALE AND SANDSTONE

21 Moderately deep to shallow, dark-colored soils

AREAS DOMINATED BY SOILS OVER SHALE, SANDSTONE, AND IN ALLUVIUM

22 Deep to shallow, light-colored and dark-colored soils

AREAS DOMINATED BY SOILS IN GRAVELLY AND COBBLY OUTWASH

23 Deep, dark-colored soils

AREAS DOMINATED BY SOILS OVER SEDIMENTARY AND IGNEOUS ROCKS, COLLUVIUM, AND TILL

24 Moderately deep to shallow, light-colored soils

25 Deep to shallow, dark-colored soils with light-colored subsurface horizons

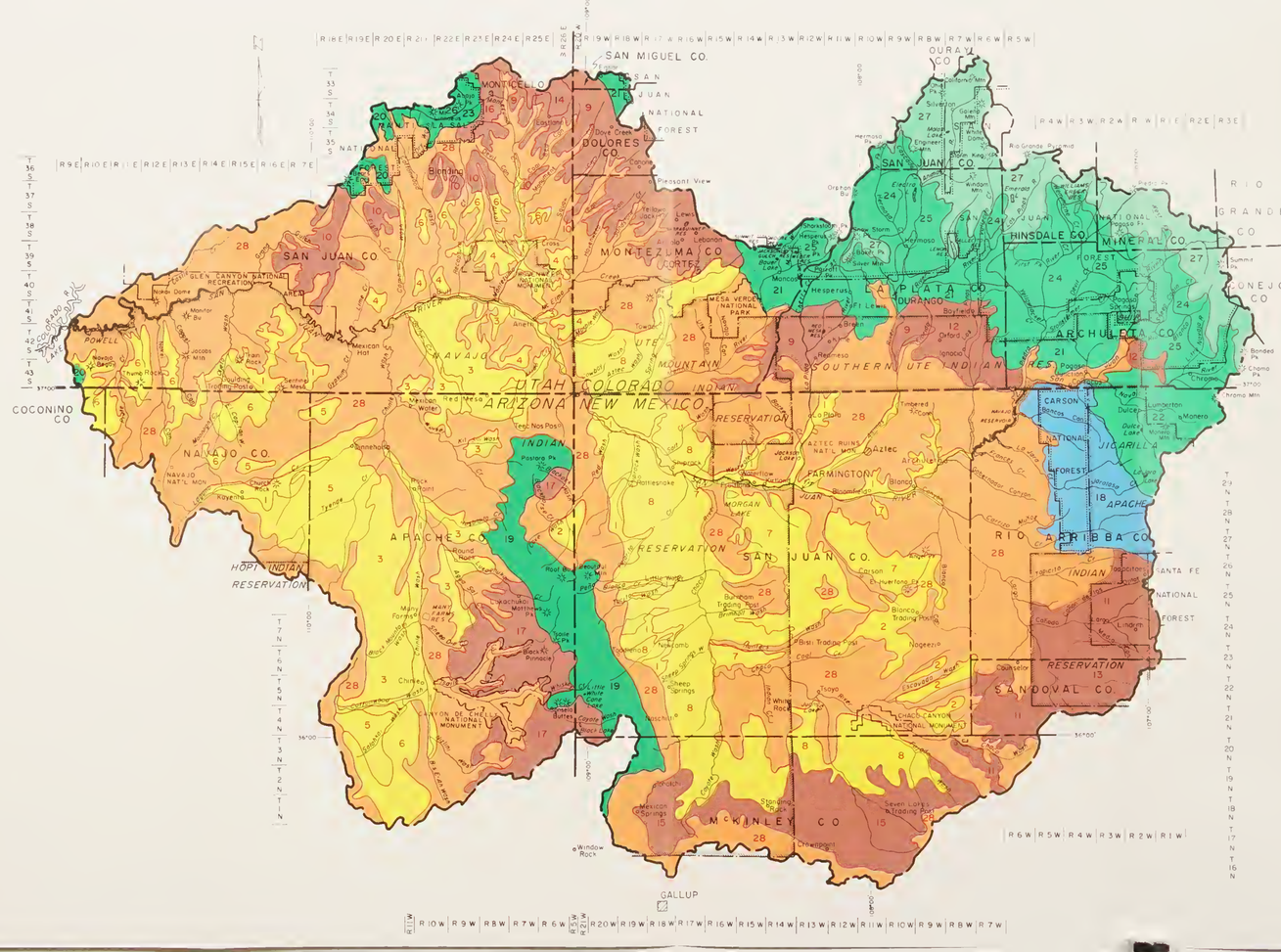
26 Deep to shallow dark-colored soils

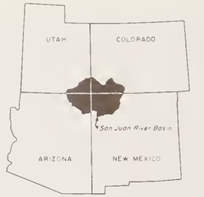
V. SOILS OF COLD HUMID SUBALPINE AND ALPINE REGIONS

27 Shallow soils, rock outcrop, and moderately deep brown-colored soils

VI. LAND TYPES AND SHALLOW SOILS

28 Rock outcrop or badlands, and shallow soils





LOCATION MAP

GENERAL SOIL MAP

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

JANUARY 1970

10 0 10 20

SCALE IN MILES

4073.2

GPO 838 310

Table III-1.- Acreage of soil mapping units and percent of area covered, San Juan River Basin in Arizona, Colorado, New Mexico, and Utah, 1970

Group	Map symbol	Acreage in Thousands of Acres and Percent									
		Arizona		Colorado		New Mexico		Utah		San Juan River Basin	
		Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
I	1	168.0	5.0	65.0	2.0	244.1	4.0	158.8	6.5	635.9	4.0
	2	14.9	0.5			164.1	2.5			179.0	1.0
	3	419.4	13.0					184.8	7.0	604.2	4.0
	4			4.0	0.5			109.9	4.0	113.9	0.5
	5	348.7	10.5							348.7	2.0
	6	256.0	8.0					119.9	4.5	375.9	2.5
	7					362.2	6.0			362.2	2.0
	8			138.0	3.5	1,072.6	17.0			1,210.6	7.5
Subtotal		1,207.0	37.0	207.0	6.0	1,843.0	29.5	573.4	22.0	3,830.4	23.5
II	9			509.9	13.5	4.0	0.5	55.9	2.0	569.8	3.5
	10			4.0	0.5			171.8	6.0	175.8	1.0
	11					356.2	5.5			356.2	2.5
	12			170.0	4.5	2.0	0.5			172.0	1.0
	13					123.1	2.0			123.1	0.5
	14							28.0	1.0	28.0	0.5
	15					455.3	7.0			455.3	3.0
	16							51.9	1.5	51.9	0.5
	17	317.1	10.0			26.0	0.5			343.1	2.0
Subtotal		317.1	10.0	683.9	18.5	966.6	16.0	307.6	10.5	2,275.2	14.5
III	18			4.0	0.5	336.2	5.5			340.2	2.0
IV	19	233.2	7.0			192.1	3.0			425.3	2.5
	20							58.9	2.0	58.9	0.5
	21			492.9	13.0					492.9	3.0
	22			28.0	0.5	204.1	3.0			232.1	1.5
	23							38.0	1.5	38.0	0.5
	24			429.9	11.5					429.9	2.5
	25			472.9	12.5					472.9	3.0
	26							24.0	1.0	24.0	0.5
Subtotal		233.2	7.0	1,423.7	37.5	396.2	6.0	120.9	4.5	2,174.0	14.0
V	27			670.9	18.0					670.9	4.0
VI	28	1,498.7	46.0	722.3	19.5	2,691.6	43.0	1,761.9	63.0	6,674.5	42.0
Total		3,256.0	100.0	3,711.8	100.0	6,233.6	100.0	2,763.8	100.0	15,965.2	100.0

Table III-2-- Dominant characteristics of soil mapping units of the San Juan River Basin in Arizona, Colorado, New Mexico, and Utah 1/

Group	Map symbol	Percent of basin	Elevation (feet)	Mean annual precipitation (inches)	Mean annual temperature (F°)	Frost free period (days)	Plant Cover Type	Soil depth	Parent materials	Slope (percent)	Runoff	Erosion Hazard	Major land uses	Potential for irrigation
I	1	4.0	4,400-6,000	6-12	48-54	147-178	Grass, Salt Desert Shrub, Northern Desert Shrub	Deep	Alluvial deposits	0-5	Slow to medium	Moderate, mainly gullying	Grazing, irrigated cropland	High
(YELLOW)	2	1.0	5,000-6,000	6-10	51-54	150-167	Grass, Northern Desert Shrub	Deep	Alluvial deposits	0-5	Medium	Moderate wind and water	Grazing	High
	3	4.0	4,600-6,000	6-8	51-54	147-156	Grass, Southern desert Shrub	Deep	Wind deposits or wind-worked materials	3-15	Slow	Moderate, wind	Grazing	Medium
	4	0.5	4,600-6,000	6-10	51-54	147-156	Grass, Southern Desert Shrub	Deep	Wind deposits or windworked materials	3-15	Medium	Moderate, wind	Grazing	Medium
	5	2.0	5,000-6,500	6-10	51-54	147-156	Grass, Southern Desert Shrub	Deep and rock outcrop	Wind deposits or windworked materials	3-15	Slow	Moderate, wind	Grazing	Medium
	6	2.5	5,200-7,000	8-12	48-53	150-178	Grass, Desert Shrub, Pinyon-Juniper	Deep to shallow	Wind deposits, sandstone and shale	0-15	Medium	Moderate, wind	Grazing	Medium
	7	2.0	5,400-7,000	6-9	51-53	149-156	Grass, Northern Desert Shrub	Deep	Sandy alluvial and wind deposits	0-15	Slow to medium	Moderate, wind	Grazing	High
	8	7.5	4,800-6,400	6-12	51-53	150-170	Grass, Salt Desert Shrub	Shallow and deep	Shale and clayey alluvial deposits	5-30	Rapid to slow	Moderate to high sheet and gully	Grazing	Low
II	9	3.5	6,000-7,000	12-17	46-48	150-158	Northern Desert Shrub, Pinyon-Juniper	Deep and moderately deep	Wind deposits	1-9	Medium to rapid	Moderate, water and wind	Dry and irrigated cropland, grazing	High
(BROWN)	10	1.0	5,800-6,400	12-14	48-50	100-150	Northern Desert Shrub, Pinyon-Juniper	Deep and moderately deep	Wind deposits	1-9	Medium to rapid	Moderate, wind	Dry cropland, grazing	High
	11	2.5	6,000-7,500	12-16	41-48	100-150	Grass, Northern Desert Shrub, Pinyon Juniper	Deep and Rockland	Wind deposits and sandstone	1-25	Slow to medium	Moderate, wind and water	Grazing	Medium
	12	1.0	6,500-7,500	12-17	46-48	100-130	Northern Desert Shrub, Pinyon-Juniper	Deep and moderately deep	Shale and clayey alluvial deposits	3-12	Medium	Moderate, water	Grazing, irrigated and dry cropland	Medium
	13	0.5	6,500-7,500	12-17	41-48	100-150	Grass, Northern Desert Shrub	Shallow to deep	Shale and clayey alluvial deposits	1-25	Medium to rapid	Moderate, water	Grazing	Low
	14	0.5	6,800-7,000	13-15	46-48	100-158	Northern Desert Shrub, Pinyon-Juniper	Deep to shallow	Shale, sandstone, and alluvial deposits	1-9	Rapid	Moderate, wind and water	Grazing, dry cropland	Medium
	15	3.0	6,400-7,400	10-16	51-57	150-170	Pinyon-Juniper	Shallow to deep	Shale, sandstone and wind deposits	3-75	Medium to rapid	Moderate wind and water	Grazing	Low
	16	0.5	6,800-7,400	14-16	46-48	129-158	Northern Desert Shrub, Mountain Brush	Deep and moderately deep	Gravelly and cobbly outwash	1-15	Medium to rapid	Moderate, wind and water	Grazing, dry and irrigated cropland	Medium
	17	2.0	6,000-8,000	14-17	46-48	100-150	Pinyon-Juniper, Northern Desert Shrub, Montane Forest	Deep and moderately deep	Residual materials and alluvium from sandstone and redbeds	1-15	Medium	Moderate, water	grazing	Medium

Table III-2— Dominant characteristics of soil mapping units of the San Juan River Basin in Arizona, Colorado, New Mexico, and Utah 1/ (continued)

III (BLUE)	18	2.0	6,200-8,000	15-25	46-48	100-150	Pinyon-Juniper, Montane Forest, Mountain Brush, Northern Desert Shrub	Moderately deep to shallow	Shale and sandstone	5-40	Medium to rapid	Moderate to high, water	Grazing	Low
IV (DARK GREEN)	19	2.5	7,000-9,000	16-25	38-46	100-125	Montane Forest, Mountain Brush, Pinyon-Juniper	Deep to shallow	Sandstone	5-75	Medium	Low to moderate, water	Timbering, grazing recreation	Low
	20	0.5	7,000-9,000	16-22	38-46	75-100	Montane Forest Mountain, Brush	Shallow	Sandstone	5-75	Medium to rapid	Low to moderate, water	Grazing, recreation, lmt. timbering	None
	21	3.0	7,000-9,000	15-20	38-46	75-115	Mountain Brush, Montane Forest	Moderately deep to shallow	Shale and sandstone	3-40	Medium	Low to moderate, water	Grazing, recreation, irrigated and dry cropland	Low
	22	1.5	6,500-8,500	15-25	43-44	75-150	Pinyon-Juniper, Mountain Brush, Montane Forest	Deep to shallow	Shale, sandstone, alluvial deposits	0-40	Medium to rapid	Moderate to high, water	Grazing, timbering, recreation	Low
	23	0.5	7,400-8,200	16-22	47	75-125	Northern Desert Shrub, Mountain Brush, Pinyon-Juniper	Deep	Gravelly and cobbly outwash	1-15	Medium	Low to moderate, water	Grazing, recreation	Low
	24	2.5	8,000-11,000	20-30	25-42	Usually frost every month	Montane Forest	Moderately deep to shallow	Sedimentary and igneous rocks, colluvium and till	10-60	Medium	Low to moderate, water	Timbering and grazing, recreation and water yield	Low
	25	3.0	7,500-11,000	20-30	25-42	Usually frost every month	Montane Forest	Deep to shallow	Sedimentary and igneous rocks, colluvium and till	15-65	Medium	Low, water	Grazing and timbering, recreation and water yield	Low
	26	0.5	8,000-11,000	22-30	47	Usually frost every month	Montane Forest	Deep to shallow	Sedimentary and igneous rocks, colluvium and till	3-65	Medium to slow	Low, water	Timbering and grazing recreation and water yield	None
V (LIGHT GREEN)	27	4.0	10,000-13,000	30-50+	25-42	Usually frost every month	Subalpine Forest, Alpine	Shallow and moderately deep	Sedimentary and igneous rocks, colluvium and till	10-80	Medium to slow	Low, water	Timbering and grazing, recreation and water yield	None
VI (ORANGE)	28	42.0	4,000-7,500	6-16	42-54	100-170	Grass, Pinyon-Juniper, Barren	Shallow and rock outcrop	Sandstone, shale, and colluvium	0-75	Rapid	Moderate to high	Grazing and recreation	Low

1/ These interpretations are intended for general planning. Each mapping unit is an association of different soils maps should be used for operational planning.

Group I: *Soils of Warm Arid to Dry Semiarid Regions*
(YELLOW)

These soils are located within the lowest precipitation and elevation zones of the Basin.

They are in all states, but are most extensive in Arizona and New Mexico. The group occupies 23.5 percent of the basin and is exceeded in acreage only by Group VI.

Soils Group I - Irrigated cropland
Farmington, New Mexico SCS PHOTO

Mean annual precipitation ranges from 6 to 12 inches and the frost-free period is long, ranging from 147 to 178 days. Elevations are mainly between 4,500 and 6,500 feet and mean annual temperatures between 48 and 54°F.

Grass and saltdesert shrub, along with southern and northern desert shrub, are the dominant cover types. They occupy slopes that typically range from 0 to 15 percent.

There are eight soil mapping units in this group which have a high proportion of deep soils. Alluvial and wind deposits are the chief soil parent materials. Major Great Groups are: Torrifluvents, Torriorthents, Torripsamments, Camborthids, and Calciorthids.

These soils have the most favorable climate for irrigated crops and are occupied by approximately 75,000 acres of the presently irrigated cropland. There is a potential for additional irrigation development. Grazing is the major land use at present and there is no dry cropland.

Group II: Soils of Warm Semiarid to Dry Subhumid Regions (BROWN)

This group constitutes 14.5 percent of the basin and consists of soils that are of moderate extent in all the states. Most of the 367,000 acres of dry cropland are located on these soils and approximately 122,000 acres are irrigated.

Soils Group II - Cropland with dry beans near Dove Creek, Colorado SCS PHOTO

There is a range of 12 to 17 inches in mean annual precipitation and the frost-free period ranges from 100 to 170 days. Elevations are mainly 6,000 to 7,500 feet and mean annual temperatures are

dominantly 46-48°F. Grass, northern desert shrub and pinyon-juniper on slopes of 1 to 15 percent are the most extensive cover types.

There are nine map units in this group. The largest is unit 9 which occupies 3.5 percent of the basin and along with unit 10 constitutes a large acreage of deep and moderately deep soils formed in wind deposits. Other extensive soil parent materials within the group are shale, sandstone, outwash, and alluvial deposits. Major Great Groups are: Argiustolls, Haplustolls, Haplargids, Camborthids, Torriorthents, Torripsamments, and Torrifluvents.

These soils have a climate suitable for both dry and irrigated cropland production although at present grazing is the chief land use. There is a medium to high potential for irrigation except for soil units 13 and 15 which have significant components of shallow soils and land types.

Group III: Soils of Warm Subhumid Mountain Regions (BLUE)

Soils of this group are all within map unit 18 which is confined to New Mexico and Colorado. It constitutes 2.0 percent of the basin.

Mean annual precipitation ranges from 15 to 25 inches and there is a frost-free period of 100 to 150 days. Elevations are from 6,200 to 8,000 feet and the mean annual temperatures are 46 to 48°F.

Pinyon-juniper and Montane Forest are the dominant cover types, but northern desert shrub and mountain brush are on significant acreages.

Moderately deep and shallow soils are typical of the group. Most of the soils have formed over shale or sandstone but some are in colluvial and alluvial deposits. Slopes are chiefly from 5 to 40 percent. Major Great Groups are: Argiustolls, Haplustolls, Haplargids, Haplustalfs, and Argiborolls. About 25 percent of the area consists of land types such as rockland and canyons.

These soils are used mainly for grazing and have a low potential for irrigation because of lack of effective depth and steep irregular slopes.

Soils Group III - Carson National Forest, New Mexico
SCS PHOTO

Group IV: Soils of Cool to Cold Subhumid Mountain Regions (DARK GREEN)

Soils of this group are moderately extensive and occupy 14.0 percent of the basin. The largest acreage is in Colorado, but there is a significant acreage in each of the other three states.

Mean annual precipitation ranges from 15 to 30 inches and the frost-free period is relatively short. There is usually a frost every month within some of the map units, but others have frost-free periods as long as 125 to 150 days at certain locations. Elevations are mostly between 7,000 and 11,000 feet where the mean annual temperature is less than 47° F.

Montane Forest is the characteristic cover type, but Mountain Brush is extensive and there is some pinyon-juniper.

These soils are in the mountainous parts of the basin and are on slopes that usually range from 3 to 75 percent.

Soil parent materials are sandstone, shale, gravelly and cobbly outwash, and alluvium. Typically the map units are composed of both deep and shallow soils and include significant acreages of rock outcrop.

There are eight map units in this group, but three have small acreages that individually only constitute 0.5 percent of the basin. Extensive Great Groups are: Argiborolls, Haploborolls, Cryoboralfs, and Eutroboralfs.

Soils Group IV - San Juan National Forest, Colorado
SCS PHOTO

Grazing, recreation, and timbering are major land uses for these soils. The generally short growing season restricts choice of crops, and there is only a low potential for irrigation. Approximately 54,000 acres are presently irrigated and about 17,000 acres are in dry cropland.

Group V: Soils of Cold Humid Subalpine and Alpine Regions (LIGHT GREEN)

This group, which only occupies four percent of the basin, is confined to the high mountains of Colorado.

Mean annual precipitation is the highest for the basin and ranges from 30 to 50 inches. There is usually a frost every month. Elevations range from 10,000 to 13,000 feet, and there is a mean annual temperature of 25 to 42° F.

Subalpine Forest and Alpine cover types dominate the rugged mountains and windswept peaks characteristic of this group. Slopes are steep, usually 10 to 80 percent in gradient.

Sedimentary and igneous rocks, colluvium, and till are the principal materials in which the soils have formed. Most of the soils are shallow or moderately deep and rock outcrop may occupy as much as 30 percent of a delineation.

Map unit 27 includes all of these soils. Great Groups are principally Cryorthents, Cryochrepts, and Cryorthods.

Soils Group V - Near Silverton, Colorado
SCS PHOTO

Recreation, timbering, water yield, and grazing are major uses made of these soils which are essentially all within the national forest. There is no potential for irrigation.

Group VI: Land Types and Shallow Soils
(ORANGE)

This is the largest group as it covers 42 percent of the basin and, there is a vast acreage in each state. All of the soils are within map unit 28.

Precipitation ranges from 6 to 16 inches annually and there is a frost-free period of 100 to 170 days. Elevations are between 4,000 and 7,500 feet and the mean annual temperature is 42 to 54° F.

Grass and Pinyon-juniper are the common cover types. Characteristically, vegetative cover is sparse and there are many barren areas.

Deep sandstone canyons, steep slopes bordering drainageways, rock outcrops and badlands are prominent features of this group. Slopes are extremely variable, ranging from 0 to 75 percent.

Sandstone, shale, and colluvial deposits are the principal parent materials, and the soils are shallow. Narrow bands of deep alluvial soils along drainageways are inclusions.

Grazing is the principal use of these soils although spectacular scenic views are a definite recreational asset. The irrigation potential is restricted to minor acreages of scattered alluvial soils.

Soils Group VI - Canyon Largo, New Mexico
SCS PHOTO

Land Use

Major agricultural uses of land in the basin are farming, grazing, and forestry. Their relationships are shown in Tables III-3 through III-7 by major cover types, and in Table III-8 for gross areas used for grazing.

Irrigated cropland occupies approximately 1.6 percent of the land area, but is an important asset to farmers and ranchers. Most of the irrigated acreage is used to raise feed which supplements the forage supplied by the range. Range management is often dependent upon irrigated lands to furnish the additional animal unit months of feed required when the livestock are not on the range.

Dry cropland is used largely for bean, wheat, and oat production. There is a recent trend of converting the poorer production areas to grass.

Table III-3.--Land areas by cover types and related categories, river basin totals, San Juan River Basin

Cover Types and Related Categories	National Forest	Private	National Park Service	Indian Lands 1/	Bureau of Land Management	State and Local Government	River Basin Total
	Acres						
Alpine	157,600	0	0	0	11,000	0	168,600
Forest	1,373,600	698,500	61,000	1,885,700	946,900	226,200	5,191,900
Coniferous forest	957,200	178,500	2,600	413,700	35,300	13,500	1,600,800
Hardwood forest	206,300	58,900	0	0	10,500	5,900	281,600
Pinyon-Juniper Woodland	147,500	411,600	58,400	1,440,400	900,100	203,300	3,161,300
Mountain Brush	62,600	49,500	0	31,600	1,000	3,500	148,200
Range	65,700	693,000	11,100	6,222,600	1,717,800	188,000	8,898,200
Grass & Forbs	46,700	389,300	0	3,624,400	596,100	104,400	4,760,900
Northern Desert Shrub	19,000	175,200	11,100	477,200	841,300	33,300	1,557,100
Saltdesert Shrub	0	128,500	0	994,500	32,900	45,300	1,201,200
Southern Desert Shrub	0	0	0	1,126,500	247,500	5,000	1,379,000
Cultivated	0	574,900	0	52,400	0	0	627,300
Irrigated	0	207,700	0	49,100	0	0	256,800
Dryland	0	367,200	0	3,300	0	0	370,500
Urban	0	40,000	100	11,100	600	0	51,800
Barren & Other 2/	16,000	39,200	2,600	692,800	155,200	81,800	987,600
Water 3/	2,900	5,000	12,900	10,200	8,000	800	39,800
Total	1,615,800	2,050,600	87,700	8,874,800	2,839,500	496,800	15,965,200

1/ Includes federal, private, and trust lands (Indian lands).
2/ Includes areas of no natural vegetation, bodies of water of less than 40 acres and streams of less than 1/8-mile in width.
3/ Includes water surfaces having 40 acres or more of area and streams of 1/8-mile or more in width.

Source: Modified from the Upper Colorado Region Comprehensive Framework Study, Appendix VI.

Table III-4-Land areas by cover types and related categories in Arizona, San Juan River Basin

Cover Types and Related Categories	National Park Service	Indian Lands 1/	Arizona Total
	Acres	Acres	Acres
Alpine	0	0	0
Forest	400	499,000	499,400
Coniferous Forest	0	98,000	98,000
Hardwood Forest	0	0	0
Pinyon-Juniper Woodland	400	401,000	401,400
Mountain Brush	0	0	0
Range	0	2,242,000	2,242,000
Grass and Forbs	0	787,000	787,000
Northern Desert Shrub	0	148,000	148,000
Salt Desert Shrub	0	667,000	667,000
Southern Desert Shrub	0	640,000	640,000
Cultivated	0	10,800	10,800
Irrigated	0	10,800	10,800
Dryland	0	0	0
Urban	0	4,000	4,000
Barren and Other 2/	0	498,800	498,800
Water 3/	0	1,000	1,000
Total	400	3,255,600	3,256,000

1/ Includes Federal, private, and trust lands. (Indian Lands)

2/ Includes areas of no natural vegetation, bodies of water of less than 40 acres, and streams of less than 1/8 mile in width.

3/ Includes water surfaces having 40 acres or more of area, and streams of 1/8 mile or more in width.

Source: Modified from the Upper Colorado Region Comprehensive Framework Study. Appendix VI.

Table III-5--Land areas by cover types and related categories, San Juan River Basin in Colorado

Cover Types and Related Categories	Forest Service	Private	National Park Service	Indian Lands 1/	Bureau of Land Management	State and Local Government	Colorado Total
	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Alpine	157,600	0	0	0	11,000	0	168,600
Forest	1,099,100	402,500	38,800	440,500	201,100	14,500	2,196,500
Coniferous Forest	854,400	164,000	2,600	77,400	34,100	6,000	1,138,500
Hardwood Forest	182,700	50,400	0	0	10,400	1,600	245,100
Pinyon-Juniper Woodland	13,300	140,600	36,200	331,500	156,600	5,400	683,600
Mountain Brush	48,700	47,500	0	31,600	0	1,500	129,300
Range	44,500	436,600	10,400	270,400	58,200	17,800	837,900
Grass and Forbs	41,700	261,800	0	160,400	29,600	10,200	503,700
Northern Desert Shrub	2,800	141,900	10,400	42,600	13,700	6,500	217,900
Salt Desert Shrub	0	32,900	0	67,400	14,900	1,100	116,300
Southern Desert Shrub	0	0	0	0	0	0	0
Cultivated	0	390,000	0	18,600	0	0	408,600
Irrigated	0	168,100	0	18,600	0	0	186,700
Dryland	0	221,900	0	0	0	0	221,900
Urban	0	19,000	0	1,100	0	0	20,100
Barren and Other 2/	3,500	20,900	2,600	18,800	20,700	3,000	69,500
Water 3/	2,900	4,600	0	2,600	0	500	10,600
Total	1,307,600	1,273,600	51,800	752,000	291,000	35,800	3,711,800

1/ Includes Federal, private, and trust lands. (Indian Lands)

2/ Includes areas of no natural vegetation, bodies of water of less than 40 acres, and streams of less than 1/8 mile in width.

3/ Includes water surfaces having 40 acres or more of area, and streams of 1/8 mile or more in width.

Table III-6.--Land areas by cover types and related categories, San Juan River Basin, New Mexico

Cover Types and Related Categories	National Forest	Private	National Park Service	Indian Lands 1/	Bureau of Land Management	State and Local Government	New Mexico Total
	Acres						
Alpine	0	0	0	0	0	0	0
Forest	127,800	223,000	21,600	691,700	390,800	122,200	1,577,100
Coniferous forest	58,000	14,500	0	238,300	1,200	7,500	319,500
Hardwood forest	0	8,500	0	0	100	4,300	12,900
Pinyon-Juniper Woodland	67,700	200,000	21,600	453,400	389,500	110,400	1,242,600
Mountain Brush	2,100	0	0	0	0	0	2,100
Range	14,000	246,400	700	2,918,700	1,115,700	128,600	4,424,100
Grass & Forbs	0	122,500	0	2,377,000	460,900	72,200	3,032,600
Northern Desert Shrub	14,000	28,300	700	281,600	654,800	14,200	993,600
Saltdesert Shrub	0	95,600	0	260,100	0	42,200	397,900
Southern Desert Shrub	0	0	0	0	0	0	0
Cultivated	0	42,800	0	22,200	0	0	65,000
Irrigated	0	34,300	0	18,900	0	0	53,200
Dryland	0	8,500	0	3,300	0	0	11,800
Urban	0	15,000	100	5,000	600	0	20,700
Barren & Other 2/	0	16,300	0	65,900	16,500	31,800	130,500
Water 3/	0	400	12,900	2,600	0	300	16,200
Total	141,800	543,900	35,300 4/	3,706,100	1,523,600	282,900	6,233,600

1/ Includes federal, private, and trust lands (Indian lands)
2/ Includes areas of no natural vegetation, bodies of water of less than 40 acres, and streams less than 1/8-mile in width.
3/ Includes water surfaces having 40 acres or more of area and streams of 1/8-mile or more in width.
4/ Includes 13,800 acres in other federal ownership.

Source: Modified from the Upper Colorado Region Comprehensive Framework Study, Appendix VI.

Table III-7-- Land areas by cover types and related categories, San Juan River Basin in Utah

Cover Types and Related Categories	Forest Service	Private	National Park Service	Indian Lands 1/	Bureau of Land Management	State and Local Government	Utah Total
	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Alpine	0	0	0	0	0	0	0
Forest	146,700	73,000	200	254,500	355,000	89,500	918,900
Coniferous Forest	44,800	0	0	0	0	0	44,800
Hardwood Forest	23,600	0	0	0	0	0	23,600
Pinyon-Juniper Woodland	66,500	71,000	200	254,500	354,000	87,500	833,700
Mountain Brush	11,800	2,000	0	0	1,000	2,000	16,800
Range	7,200	10,000	0	791,500	543,900	41,600	1,394,200
Grass and Forbs	5,000	5,000	0	300,000	105,600	22,000	437,600
Northern Desert Shrub	2,200	5,000	0	5,000	172,800	12,600	197,600
Salt Desert Shrub	0	0	0	0	18,000	2,000	20,000
Southern Desert Shrub	0	0	0	486,500	247,500	5,000	739,000
Cultivated	0	142,100	0	800	0	0	142,900
Irrigated	0	5,300	0	800	0	0	6,100
Dryland	0	136,800	0	0	0	0	136,800
Urban	0	6,000	0	1,000	0	0	7,000
Barren and Other 2/	12,500	2,000	0	109,300	118,000	47,000	288,800
Water 3/	0	0	0	4,000	8,000	0	12,000
Total	166,400	233,100	200	1,161,100	1,024,900	178,100	2,763,800

1/ Includes Federal, private, and trust lands. (Indian Lands)

2/ Includes areas of no natural vegetation, bodies of water of less than 40 acres, and streams of less than 1/8 mile in width.

3/ Includes water surfaces having 40 acres or more of area, and streams of 1/8 mile or more in width.

Table III-8-- Rangeland livestock forage production, San Juan River Basin, 1965

States	Private	Bureau of Land Management	Forest Service	Indian Lands	State and Local Government	Total
Arizona						
Gross Area Used For Grazing (acres)	0	0	0	2,741,000	0	2,741,000
Total Forage Production (AUM's)	0	0	0	225,500	0	225,500
Colorado						
Gross Area Used For Grazing (acres)	815,000	262,000	598,700	739,000	30,000	2,444,700
Total Forage Production (AUM's)	93,600	20,800	85,200	27,900	3,400	230,900
New Mexico						
Gross Area Used For Grazing (acres)	400,000	1,347,000	93,800	3,815,000	200,000	5,855,800
Total Forage Production (AUM's)	34,000	192,100	5,200	334,100	17,000	582,400
Utah						
Gross Area Used For Grazing (acres)	83,000	898,900	71,900	1,046,000	131,100	2,230,900
Total Forage Production (AUM's)	13,300	30,900	12,800	49,900	21,000	127,900
River Basin Total						
Gross Area Used For Grazing (acres	1,298,000	2,507,900	764,400	8,341,000	361,100	13,272,400
Total Forage Production (AUM's)	140,900	243,800	103,200	637,400	41,400	1,166,700

Recreation is a major use of land in the basin and is generally compatible with other resource uses. The water areas have increasingly heavy recreation uses for boating, fishing, water skiing, and general vacationing.

Mining, transportation, utilities, and urban areas occupy a small percent of the land area for high value purposes. Mining, for example, presently uses relatively few surface acres to exploit the underground mineral resources, and this is particularly true in regard to oil and gas production.

Land Ownership

The basin has four Indian reservations which are prominent in the ownership pattern. The largest of these is the Navajo Reservation including about 7,391,400 acres which extend into New Mexico, Arizona and Utah. The Ute Mountain Ute Indian land is composed of about 448,000 acres in Colorado; 107,500 acres in New Mexico, and 13,500 acres in Utah. The Southern Ute Indian land is composed of 300,000 acres in Colorado. Jicarilla Apache land area occupies about 614,000 acres in New Mexico. The remaining Indian land is within the Navajo Reservation. No attempt was made to separate the Indian Trust Lands, the tribal-owned fee patent lands, the individually owned Indian Trust allotments, or the Bureau of Indian Affairs federally owned land. They are all included in the table as Indian land. The private non-Indian land is 13.1 percent of the basin total, and is in all states except Arizona. State and local government land is 2.9 percent of the basin total with the majority being state land.

Federal land is administered by the Bureau of Land Management, the Forest Service, and the National Park Service. Forest Service land in the basin includes a large part of the San Juan National Forest in Colorado; portions of the Carson and Santa Fe National Forests in New Mexico, and a portion of Manti-La Sal National Forest in Utah.

National Park land is composed of Mesa Verde National Park, Yucca House National Monument, and a portion of Hovenweep National Monument in Colorado. In New Mexico, the National Park Service has Aztec ruins and Chaco Canyon National Monuments. In Arizona, National Park Service areas include a portion of Navajo National Monument, and all of Canyon de Chelly National Monument. However, the Canyon de Chelly land area is considered as Navajo Indian ownership. In Utah, a very few acres of Natural Bridges and Hovenweep National Monuments are in the basin.

Details of the landownership pattern are shown on the Land Ownership Map on the following page. Tabular information on land ownership is given in Table III-9.

Cover Conditions and Management

Cover conditions vary from dense virgin forest to nearly barren desert areas. Total water production follows the same pattern and is generally related to the same factors of elevation, exposure, and effective climate that produce the variations in cover.

Management of the plant cover is of particular importance in this basin because of the limited regrowth possibilities imposed by climate and precipitation. Sediment production is directly related to the kind and amount of plant cover. Most of the higher sediment producing areas are the more arid, poorly vegetated soils. The irrigated and dry cropland cultivated land contribute to the sediment production. The principal erosive areas, however, are the arid rangelands.

The Land Use and Plant Cover Map following Table III-9 illustrates the general location of cover types in the basin.

IRRIGATED CROPLAND

There are 256,800 acres of irrigated cropland in the basin: 10,800 acres are in Arizona; 186,700 acres are in Colorado; 53,200 acres in New Mexico, and 6100 acres in Utah. Most of this land is used for hay and pasture. Corn, usually used for silage and small grains account for most of the remainder. The hay, pasture, and silage yields contribute to the total forage and feed for livestock and wildlife of the basin, and are a vital supplement to the grazing land. Vegetable and fruit farming has limited acreage and is generally in the Durango-Cortez-Farmington areas.

DRY CROPLAND

Dry cropland constitutes 2.3 percent of the basin area (Table III-3). Most of this land is in the Cortez-Dove Creek-Monticello area and is a dry bean production center. Small grain, principally winter wheat, is another leading crop.

The combination of suitable soils, and a frost-free period which fits both the planting and harvest dates, has led to a considerable expansion in dry bean farming since the middle 1940's. This expansion in acreage is still going on in the Cortez-Dove Creek-Monticello

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LOCATION MAP

LAND OWNERSHIP STATUS

- Lands administered by the Bureau of Land Management: withdrawals and reservations primarily under B. L. M. jurisdiction and vacant public lands.
- Privately owned land, patented, R. R., mining and small holding claims, corporations, cities, etc.
- National forest lands, administered by the U. S. Forest Service.
- State owned lands, including those under contral and title of State Fish and Game Departments.
- Indian Reservations and lands.
- National Parks and Monuments.
- Numerous mining claims.

GENERALIZED
LAND OWNERSHIP MAP

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

JULY 1972

10 0 10 20 MILES

SCALE 1:1,150,000

M7-S-22573-N

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LOCATION MAP

LEGEND

A ALPINE

CROPLAND

Irrigated Lands

Dry Cropland

FORESTS & RANGELANDS

SF Subalpine Forest

MF Montane Forest

MB Mountain Brush & Rangelands

Pinyon-Juniper Woodland & Rangelands

Grass

Northern Desert Shrub

Southern Desert Shrub

Saltdesert Shrub

sh Shadscale

gw Greasewood

LAND USE & PLANT COVER

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

OCTOBER 1972

10 0 10 20 MILES

SCALE 1:1,150,000

Source: Upper Colorado Region Comprehensive Framework Study

M7-S-22573E-N

USDA SCS-PORTLAND OREGON 1972

area and has resulted in the development of consiserable acreages of grass, pinyon-juniper and sagebrush types of vegetation. Extension of the area to the higher elevation San Juan-Dolores River Basin divide has resulted in encroachment on the frost-free period necessary for the beans. Wheat and grass plantings are substitutions in these areas. The present bean acreage expansion is largely within the existing production area and is accomplished by subjugation of previously bypassed brush areas which were more expensive to bring under cultivation. Many existing fields are being squared off by elimination of odd areas of brush which were not intially removed.

Aside from the dry bean production area, the cultivated dry farm cropland acreage will remain low, and perhaps decrease. This is mainly due to climatic conditions which preclude the opportunities for continually increasing yields to compensate for increased farming costs. Conversions to pasture seeding for livestock use are becoming increasingly popular.

PLANT COVER AND RELATED CATEGORIES

The following is a general description of plant cover communities as they exist throughout the basin. The categories of cropland, urban, water and barren are included in this general description in lieu of plant cover. The plant biotic communities used as categories in this section are basically equivalent to ecological units or associations; thus, these terms should be considered synonymous.

This section is concerned with vegetative cover which is quite distinct from land use. For example, commercial timber production is a use of some forest lands, but certainly not of all. Grazing of cattle as a land use occurs on both range and forested lands.

Plant cover is extremely significant to the planner in that it is an excellent indicator of the use potential of the land. Alpine biotic communities, due to their delicate balance, cannot absorb more than minimal use. Their two primary uses to man are as watershed and as an opportunity for a visually aesthetic experience. Contrasted with the fragility of the alpine community is the stability of the forest association. Here, manipulation of the biotic community is more successful as long as all ecological factors are taken into account. The major present products of the forest are forage, recreation, water, wildlife and wood. The range biotic communities are, for the most part, stable. However, areas of extremely low rainfall may exhibit retarded recuperation following disturbance. The major function of rangeland vegetation is for production of forage. This biotic community, however, additionally serves as a vital protective cover of the soil against wind and water erosion.

Symbol and/or color references are included in parenthesis for those types shown on the Land Use and Plant Cover Map.

Tables III-3 through III-7 give acreages of plant cover types and related categories by ownership and land administering agencies. Table III-10 gives county acreages of these plant cover types. Acreages in these tables should not be compared to the area delineation for acreage totals as represented on the map because of the generalized nature of the map and the inclusions which are recognized as being in the cover type map delineations. The tables more nearly represent the acreage taken from agencies' statistical reports, and are rounded and adjusted to total the accepted basin and state acreages for land and water area totals.

Alpine (A-Grey) _____

The alpine plant association occur above the timberline at elevations about 11,500 feet. The growing season at this elevation is short and the climate, even in summer, is severe. Vegetative production is meager and the plant communities are fragile, exhibiting extremely slow recuperation rates following disturbance. The species usually found in the alpine meadow are sedges, bluegrasses, spike trisetum, alpine timothy, willows, bistort, bluebells, gentian, clovers, and kobresia.

Alpine barren areas include those alpine areas on which there is no natural vegetation, or practically none including shale, rock slides, snow fields, and glaciers.

Forest (light and dark green) _____

Forest vegetation is below the alpine zone and above the rangelands in elevations. It is limited at high elevations by severity of climate and shortness of growing season, and limited at lower elevations by low precipitation. The forest provides the basis of a stable biotic community usually resistant to surface erosion. Some forest lands produce excellent forage as an understory plant product. This forage complements rangeland forage in that it is in prime condition for grazing during the summer months, when rangelands are generally dormant due to dryness.

Subalpine Forest (SF-dark green) _____

At higher elevations in the subalpine forest, which is sometimes called the spruce-fir forest, the dominant trees are Englemann spruce and subalpine fir. At the lower elevations in the subalpine

Table III-10.--Acreages of plant cover types and related categories by states and counties, San Juan River Basin

State and County	Related Categories: Miscellaneous: Water 1/	Miscellaneous: Barren and Other 2/	Miscellaneous: Urban	Cultivated: Irrig.	Cultivated: Dryland	Forest: Alpine	Forest: Coniferous Forest 3/	Forest: Hardwood Forest 3/	Range: Pinyon-Juniper Woodland	Range: Mountain Brush	Range: Grass and Forbs	Range: Northern Desert Shrub	Range: Salt-desert Shrub	Range: Southern Desert Shrub	Total
	(1,000 Acres)														
ARIZONA															
Apache	1.0	387.8	3.0	10.4	0	0	98.0	0	226.2	0	637.0	148.0	667.0	368.6	2,547.0
Coconino	0	1.0	.1	0	0	0	0	0	25.2	0	0	0	0	0	26.3
Navajo	0	110.0	.9	.4	0	0	0	0	150.0	0	150.0	0	0	271.4	682.7
Total	1.0	498.8	4.0	10.8	0	0	98.0	0	401.4	0	787.0	148.0	667.0	640.0	3,256.0
COLORADO															
Archuleta	3.0	18.0	4.6	20.0	15.9	0	472.1	95.0	125.5	6.0	10.0	55.0	0	0	825.1
Conejos	0	.6	0	0	0	0	2.7	.3	0	0	0	0	0	0	3.6
Dolores	0	2.0	2.1	0	83.5	0	0	.5	12.0	0	3.0	41.1	0	0	144.2
Hinsdale	.6	4.6	.2	4.5	0	42.1	93.7	23.0	0	2.0	3.5	0	0	0	174.2
LaPlata	5.2	26.0	5.1	105.0	35.7	42.2	301.0	70.7	216.7	60.0	132.3	66.0	16.3	0	1,082.2
Mineral	.1	5.0	1.0	1.2	0	0	120.8	20.0	0	2.0	3.0	0	0	0	153.1
Montezuma	1.3	8.1	5.1	56.0	82.2	0	40.0	10.0	328.8	58.8	347.9	42.3	100.0	0	1,080.5
Rio Grande	0	.5	0	0	0	0	4.7	0	0	0	0	0	0	0	5.2
San Juan	.4	4.4	1.6	0	0	84.3	103.5	25.6	0	.5	2.0	0	0	0	222.3
San Miguel	0	.3	.4	0	4.6	0	0	0	.6	0	2.0	13.5	0	0	21.4
Total	10.6	69.5	20.1	186.7	221.9	168.6	1,138.5	245.1	683.6	129.3	503.7	217.9	116.3	0	3,711.8
NEW MEXICO															
McKinley	.4	26.3	1.2	.8	0	0	32.5	1.3	86.2	.5	870.6	110.0	12.0	0	1,141.8
Rio Arriba	6.1	28.4	.8	.4	2.8	0	215.0	8.7	531.2	.5	158.9	337.8	15.0	0	1,305.6
Sandoval	0	4.0	.1	0	0	0	0	0	63.6	.1	27.7	159.7	11.0	0	266.2
San Juan	9.7	71.8	18.6	52.0	9.0	0	72.0	2.9	561.6	1.0	1,975.4	386.1	359.9	0	3,520.0
Total	16.2	130.5	20.7	53.2	11.8	0	319.5	12.9	1,242.6	2.1	3,032.6	993.6	397.9	0	6,233.6
UTAH															
San Juan	12.0	288.8	7.0	6.1	136.8	0	44.8	23.6	833.7	16.8	437.6	197.6	20.0	739.0	2,763.8
BASIN TOTAL	39.8	987.6	51.8	256.8	370.5	168.6	1,600.8	281.6	3,161.3	148.2	4,760.9	1,557.1	1,201.2	1,379.0	15,965.2

1/ Includes water surfaces having 40 acres or more of area and streams of 1/8-mile or more in width.
2/ Includes areas of no natural vegetation, bodies of water of less than 40 acres and streams of less than 1/8-mile in width.
3/ The main map delineations for this are the subalpine and montane forest areas.

forest are two species that occupy large areas. These species are Doublas fir and aspen.

Understory plants commonly found in the subalpine forest are pinegrass, bluegrass, bromegrass, fescue, wheatgrass, sedges, arnica, and huckleberry. Much of the subalpine forest has dense stands of trees and little undergrowth. Streambank and meadow communities in the subalpine forest consist of woody plants such as willows, aspen, alder and dogwood. Some of the important inerbaceous species are tufted hairgrass, bluegrass, bromegrass, bluejoint reedgrass, sedges, fescues, and rushes.

Montane Forest (MF-dark green) _____

The montane forests are characterized by the presence of Ponderosa pine, intermixed with extensive stands of aspen and Douglas fir. Ponderosa pine forms some open stands and usually has an abundance of understory plants. Some of the important plants are bromegrass, mountain muhly, timothy, Arizona fescue, Idaho fescue, wheatgrass, and oatgrass. Common shrubs are big sagebrush, serviceberry, snowberry, mountain mahogany, and bitterbrush. Streambank and meadow communities in the montane forest are similar to those in the subalpine forest. This zone also has potential for increasing water yield through intensive management of the vast areas of aspen and pine.

Typical Montane Forest near Pagosa Springs, Colorado SCS PHOTO

Mountain Brush (MB-dark green) _____

At lower elevations, mountain brush includes shrub types that commonly occur as a transition between forest and other vegetation types. Common shrubs of this type are oaks, mountain mahogany, serviceberry, ceanothus, bitterbrush, cliffrose, chokecherry, snowberry and rose. Other plants commonly found in this zone are big sagebrush, wheatgrass, needlegrass, fescues, ricegrass, muhlys, bluegrass, junegrass and annual bromes.

Pinyon-juniper Woodland (PJ-light green) _____

Occurring in foothill and low mountain areas, pinyon-juniper types are not usually abundant at elevations above 7,000 feet or below 4,000 feet. The most common junipers are Utah, Rocky Mountain and one-seed. Colorado pinyon is the most common pine in this zone.

Understory species include bitterbrush, big sagebrush, mountain mahogany and cliffrose. Some herbaceous species present are blue grama, galleta, bluegrass, bromes, fescues, Junegrass, muhlys, needlegrass, wheatgrasses, Indian ricegrass, Russian thistle and annual brome.

Range (Brown, orange, purple and yellow) _____

Range is a generalization of several specific nonforested types. Range is also commonly used as a term referring to that portion of these plant communities on which there is wildlife and livestock.

The rangelands are generally found up to an elevation of about 7,000 feet where forest types begin to dominate. Four major vegetative communities are found within the rangeland: *grass, northern desert shrub, southern desert shrub and saltdesert shrub.* The northern and southern desert shrub types are differentiated by climate, particularly temperature and timing of rainfall. Northern desert shrub occurs where a cold winter and a single wet season exists in early spring, while the southern desert shrub occurs where there is a milder winter and two seasons of moisture - both early and late fall. The saltdesert shrub, as the name implies, occurs under saline conditions. The grasslands are different from the desert shrubs in that they thrive in the higher rainfall portions of the range, usually adjacent to forest lands.

Grass (G-yellow) _____

Perennial grass-grasslands and grasslands mixed with shrubs or with forbs cover extensive areas. At the higher elevations, perennial grasses mixed with shrubs or with forbs occur as small scattered "islands". The most common perennial grasses are western wheatgrass, bluebunch wheatgrass, squirreltail and needlegrass. In the lower elevations, the most abundant perennial grasses are blue grama and galleta. Numerous species of forbs which are usually more or less temporary, having occurred due to distrubances of the vegetation, are found at all elevations.

Grassland - Ute Mountain Reservation, Colorado
SCS PHOTO

Annual grass includes areas in which annual forbs or annual grasses constitute the dominant vegetation. Both transitory stages and semi-permanent conditions are included. Species include Russian thistle and cheatgrass.

Northern Desert Shrub (ND-brown) _____

This type is identified by the presence of big sagebrush occurring in extensive zones. Big sagebrush is not as restricted by elevations as are the other communities and is found at all elevations, sometimes as high as over 10,000 feet. Sagebrush is found on well-drained, commonly loamy soils that are not usually saline. Many woody and herbaceous species are associated with big sagebrush. Some of these shrubs are black sagebrush, little rabbitbrush, horsebrush, winterfat and snakeweed. Understory grasses are galleta, blue grame, western wheatgrass, bluebunch, wheatgrass and squirreltail.

Southern Desert Shrub (SD-orange) _____

Blackbrush typifies the southern desert shrub type and grows in a zone characterized by sandy soils at lower altitudes. Plants associated with blackbrush are fourwing saltbush, Mormon tea, yucca, creosote bush, snakeweed and galleta.

Saltdesert shrub (purple) _____

This type may be further divided into two subtypes.

Shadscale (sh-purple) is limited to soils that are slightly saline and relatively impermeable. Shadscale grows in some places in nearly pure stands, but is commonly mixed with other shrubs such as sagebrush, horsebrush and spiny hopsage. Nuttall saltbush commonly occurs locally as pure stands within this zone.

Greasewood (gw-purple) growing on terraces above permanent streams and along intermittent stream channels at lower altitudes, is very salt tolerant and deep rooted, and usually indicates the presence of ground water. It usually grows as nearly pure stands, but is in some places associated with shadscale, sagebrush, saltbush and rabbitbrush. Herbaceous species commonly associated with greasewood are saltgrass and alkali sacaton, seepweed and pickleweed. Much of the area within the saltdesert shrub type which is occupied by these species is sometimes typed separately as the Salt Marsh Zone. These areas consist of the salt marshes that occupy some playa bottoms. Species occupying these areas must have the capacity to exist partially submerged in water part or all of the year, and also must have extreme salt tolerance.

Cropland (red and pink) _____

Irrigated cropland (red) is land on which water is applied artifically. The areas are scattered throughout the basin.

Types of crops produced on these lands vary from mountain meadow hay in the cold mountain valleys with short growing seasons, to a crop rotation of alfalfa hay, corn, grain, and vegetable crops in a warm desert climate.

Dry Cropland (pink) is land that will produce crops in rotation with or without fallow, and rotation hay or pasture with natural precipitation. Generally, large acreages are required to make an economic unit. Most of the lands are used to produce winter wheat and pinto beans. Winter wheat is generally produced every other year with fallow to conserve moisture. Pinto beans are produced annually.

Rotation hay and pasture has no scheduled period of rotation, but is managed to fit the weather, prices and government programs.

Urban _____

Urban is not a plant cover type and is not a map delineation. It could occur within any vegetative type. It includes towns, villages, settlements, builtup areas, roads, airports, railroads and similar type areas where cover type is not a use factor.

Barren and Others _____

This is not a plant cover and is not a map delineation, but knowledge of the acreages involved are essential to planners and users of the areas in which it occurs. This type includes areas on which there is little or no natural vegetation including intermittent lake beds, bodies of water of less than 40 acres, streams less than one-eighth mile in width, saline flats, active and dunes, shale, rock, rock slides, lava flows, etc.

Areas which have been temporarily denuded by overgrazing or other causes are not included.

Water _____

This is not a plant cover type, but is included in the tables to account for the total land and water acreage. It includes water surfaces having 40 acres or more of area, and streams one-eighth mile or more in width.

RANGELAND

The Land Use and Cover Map following page III-30 and Tables III-3 through III-8 contain the visual and tabular data relative to the rangelands in the basin. The gross area used for grazing is 13,272,400 acres and provides 1,166,700 animal unit months (AUM's) of forage production.

The generalized plant communities are self-descriptive by their names and reflect the general appearance of the various areas as located on the map. A more realistic approach to gathering range data on a river basin of this size is to make a broad scale "range site" study for interpretative analysis. This method was used in arriving at the AUM's estimated above, along with the allotment figures of the various agencies involved. A fairly detailed

reconnaissance range site study of the Colorado portion of the basin was utilized in this inventory study. The following woodlands and range site descriptive data includes the major sites representative of the basin.

Aspen, successional, is a range site generally found in the 7,000 to 11,500 feet elevation range and is growing as the result of some site disturbance in the past. Generally, it will revert to a conifer type timber zone given enough time. A representative grazing value of 15 acres per AUM is common.

Aspen, permanent type, grazeable, is generally at the 8,000 to 10,000 feet elevation range. It contains a wide variety of grazeable shrubs and grasses as understory plants. Six acres per AUM is representative of its grazing value.

Pinyon-juniper, grazeable, occurs at the lower elevations of the coniferous woodland types - 5,000 to 7,500 feet elevations are common. It is the transition zone between grasslands and the montane forests. The understory can consist of a wide variety of grasses of which Indian ricegrass, blue grame, galleta, cheatgrass, muttongrass, and prairie Junegrass are often found. Also, sagebrush, serviceberry, rabbitbrush, and snakeweed may be associated plants. A range of 10 to 20 acres per AUM is not uncommon for this site, depending on the range conditions.

Pinyon-juniper-oak, grazeable, is similar to the pinyon-juniper woodlands except it contains various amount of oak. Generally, this association is at the upper elevations of the pinyon-juniper zone and approaching the Douglas fir zone. It is valuable browse land for wildlife and generally has about the same or a little better grazing capacity than the pinyon-juniper woodlands because it is in the upper part of the pinyon-juniper precipitation zone. This woodland complex is very prominent in the Colorado portion of the basin.

Pinyon-juniper-oak, nongrazeable, is generally associated with steep, rocky, or inaccessible lands that should not be grazed.

Ponderosa Pine, grazeable, generally is at elevations of 6,000 to 8,500 feet. Associated understory plants include oak, serviceberry, mountain mahogany, and similar browse associations along with fescue, mountain muhly, western wheatgrass, and blue grama in the grass associations. This site is very prominent in the Colorado portion of the basin. Five to 20 acres per AUM is the usual range for forage production, with most sites in "fair" condition having a value of 10 acres per AUM.

Ponderosa Pine, nongrazeable, is a site with little or no understory of grazeable plants, very steep land, inaccessible areas, or thick density of trees.

Spruce-Fir, conditional grazeable, is in the 9,000 to 11,500 feet elevation zone and the precipitation range is about 25 to 35 inches. Associated understory plants include bluegrass, spike trisetum, bromegrass, wheatgrass, elk sedge, buffalo berry, alpine willows, alder, and mountain birch. Value for both forest and grazing use goes down the closer the site approaches timberline because of the stunted and dwarfed growth. Fifteen-plus acres per AUM is a common value for grazing use.

Spruce-Fir, nongrazeable, is a site with little or no understory of grazeable plants, very steep or rocky land, inaccessible areas, or thick density of trees.

Dry pasture is not considered a range site because it is usually a seeded site using non-native species with some type of site preparation for the seed plantings. Neither, in this sense, is it considered to be dry cropland. A combination of good soils, moisture conditions, slopes, and reasonable costs for preparing the site are the usual reasons for putting in dry pastures. A commonly used value for forage production is five acres per AUM.

Alpine Meadow is a range site usually found above timberline. Precipitation is mostly in the form of snow and there is only a short, cool summer. Willows, sedges, rushes, bluegrass, tufted hairgrass, and forbs characterize the site. Sedges are an important part of the composition. Two to three acres per AUM is the usual forage production.

Alpine Slopes or Alpine Grassland is a range site also found above timberline. Precipitation is mostly in the form of snow and there is only a short, cool summer. It has a mixed grass-forb aspect with sedges, rushes, kobresia, alpine bluegrass, tufted hairgrass and numerous alpine type forbs. Cinquefoil and alpine willow are the principal shrubs. The willows are seldom over a few inches tall. Forage production is in the range of four to six acres per AUM.

Brushy Loam is in the 15 to 20 inch precipitation zone and generally in the 6,000 to 9,000 elevation range. Grasses and forbs dominate the vegetation, but oak and in a few cases, serviceberry, characterize the sites aspect. Other shrubs include chokecherry, snowberry, rose, and big sagebrush. Elk sedge is the most frequent occurring plant. Slender wheat, western wheat, mountain brome, needlegrass, and fescue are the principal grasses. Five to 12 acres per AUM are the usual grazing values.

Clayey Foothills in the pinyon-juniper climatic zone where precipitation ranges from 12 to 15 inches and elevations from 5,500 to 7,000 feet. Western wheatgrass dominates the plant community. There may be some big sagebrush, rabbitbrush, and snakeweed. Other grasses include needle-and-thread, bluegrass, blue-bunch wheatgrass, Junegrass, Indian ricegrass, and squirreltail. The usual range of forage production is 10 to 15 acres per AUM, but could be better if more were in "good" condition.

Clayey Valley is in the 18 to 22 inch precipitation zone and at 7,000 to 9,000 feet in elevation. The dominant aspect of the site is grassland although Ponderosa pine may occur in limited amounts. Dominant grasses are western wheatgrass, slender wheatgrass, fescues, mountain muhly, and needlegrass. Some oak, snowberry, or black sage may occur in minor amounts. Four to 10 acres per AUM is the usual forage production range.

Clayey Saltdesert site is in the 8 to 12 inch precipitation zone and at elevations of 4,500 to 6,500 feet. It is primarily a mat saltbush-Gardner saltbush association, but may have a minor amount of galleta, wildrye, squirreltail, and Indian ricegrass, some forbs, or some woody plants such as bud sage, buckwheat brush, or rabbitbrush. Common forage production is 12 to 15 acres per AUM.

Loamy Foothills site is in the 14 to 18 inch precipitation zone with elevations of 6,000 to 7,000 feet. It is in the pinyon-juniper climatic zone. It is typical of the dry bean production center of the Cortez-Dove Creek-Monticello area referred to in the dry cropland section of LAND RESOURCES. Grasses dominate the cover, western wheatgrass generally being most plentiful. Others are Indian ricegrass, needle-and-thread, bearded wheatgrass, Junegrass, muttongrass, and galleta. Other shrubs are bitterbrush, mountain mahogany, black sagebrush, frir ed sage, and snowberry. Forage production is generally in the 8 to 10 acres per AUM range.

Loamy Saltdesert site precipitation averages less than 12 inches and elevations from 4,500 to 6,500 feet. The site has a grassland aspect. Grasses are galleta, wildrye, Indian ricegrass, needle-and-thread, thickspike wheatgrass, squirreltail, and some bluegrass. Shrubs include bud sage, winterfat, fourwing saltbush, shadscale, big sagebrush, and rabbitbrush. Forage production is generally in the 10 to 12 acres per AUM range.

Mountain Meadow site can be in the 9-inch plus natural precipitation zones, but the key to site existence is natural subirrigation or irrigation. Elevations range from 6,000 to 11,500 feet. Tufted hairgrass, slender wheatgrass, alpine timothy, sedges, and rush form a meadow aspect. Willows are a part of the plant community. Other shrubs and forbs are usually present in smaller proportions. In the

more swampy areas, water-loving plants become more prominent. Forage production is in the range of 2 to 4 acres per AUM.

Mountain Shale site is in the 18 to 22 inch precipitation zone and the 7,000 to 9,000 feet elevation range. Oak, with an understory of grasses and forbs, is a typical feature of the site. A scrubby growth of Ponderosa pine may be present. Pinyon-juniper may occur on the drier portions of the site. Typical grasses include wheatgrass, bromes, fescue, mountain muhly, needlegrass, Junegrass, and muttongrass. Ten acres per AUM is a typical forage production. With more "good" site conditions the yield could increase.

Rocky Foothills site is in the 12 to 15 inch precipitation zone and the 5,500 to 7,500 feet elevation range. It is in the pinyon-juniper climatic zone and is typically rought, rocky breaks. Grasses include Indian ricegrass, bluegrass, needle-and-thread, galleta, grama grass, Junegrass and wheatgrass. Browse plants may include big sagebrush, mountain mahogany, serviceberry, Mormon tea, and bitterbrush. Thirteen to 20 acres per AUM are typical forage productions.

Saltdesert Breaks site is in the 8 to 12 inch precipitation zone and the 4,500 to 6,000 feet elevation range. Vegetation is dominantly grasses mixed with saltdesert shrubs and a variety of perennial forbs. Galleta is the dominant grass. Other grasses are Indian ricegrass, needle-and-thread, wildrye, Junegrass, squirreltail, western wheatgrass, and native bunch bluegrass. Shadscale is the dominant shrub, but others such as juniper, yucca, cactus, Mormon tea, bud sage, and winterfat can usually be found. Generally, 12 to 15 acres are required per AUM of grazing.

Saltdesert Overflow site is in the 7 to 12 inch precipitation zone and at elevations ranging from 4,500 to 6,000 feet. Generally, they receive run-in water from adjacent areas of the watershed. The cover is mainly grasses. The principal ones are alkali sacaton and galleta. Others may be Indian ricegrass, sand dropseed, squirreltail, and slender wheatgrass. Browse species, usually only in minor amounts, are fourwing saltbush and big sagebrush. Greasewood may be a minor component of the vegetation. Generally 7 acres are required per AUM of grazing.

Salt Flats site has from less than 8 to over 12 inches of precipitation, and elevations range from 4,500 to 6,000 feet. Only rarely does the land support perennial grasses. Major vegetation is usually greasewood with an understory of annual weeds and grasses. In some areas the principal vegetation is a mat saltbush-Gardner's saltbush association. Sagebrush, western wheatgrass, galleta, fourwing saltbush, and Indian ricegrass are examples of better type vegetation that should grow and can still be found on this site in some areas. Generally, 12 plus acres are required per AUM.

Subalpine Loam site is in the over 20-inch precipitation zone with elevations of 8,000 to 11,500 feet and generally, is in the spruce-fir zone in open parks. It forms a true grassland aspect. Thurber fescue is the dominant species. Other grasses include nodding brome, wheatgrass, big bluegrass, and fescues. Shrubs present in small quantities include mountain big sagebrush, silver sagebrush, snowberry, and shrubby cinquefoil. Forage production is in the two to five acres per AUM range.

FORESTLAND

The importance of the forests for wood, recreation, forage for domestic livestock and wildlife, water, and other values is substantial.

The forest acreage is expected to remain fairly constant, with a decrease of not more than one percent during the projected period. Multiple use management of the forested lands will intensify in the future. Agriculture, urban development, construction of roads, reservoirs, power lines, recreation areas, and other uses are expected to cause the slight reduction of forest acreage. Because of lower elevations, gentler slopes, and better accessibility the Ponderosa pine type is especially susceptible to reduction as a result of urban development.

Forests of the San Juan River Basin include a number of major timber types (Table III-11). Distribution of the various species is influenced by elevation above sea level, precipitation, direction of slope and characteristics, length of growing season and other factors.

Pinyon-juniper trees grow at the lowest elevation on areas receiving from 10 to 16 inches of precipitation a year. Above the 16-inch precipitation zone, the general progression of species is (1) Ponderosa pine, (2) aspen, Douglas-fir, white fir, (3) subalpine fir and Englemann spruce.

Table III-11.--Distribution of forest area in the basin by states and ownership classes, San Juan River Basin, Arizona, Colorado New Mexico and Utah - 1969

State	All Ownership	National Forests	BLM	National Parks	Indian Lands	State and Private	Percent
Arizona	499,400			400	499,000		9
Colorado	2,196,500	1,099,100	201,100	38,800	440,500	417,000	41
New Mexico	1,774,500	151,200	390,800	12,600	833,400	386,500	33
Utah	918,900	146,700	355,000	200	254,500	162,500	17
TOTAL	5,389,300	1,397,000	946,900	52,000	2,027,400	966,000	100

Source: U.S. Forest Service.

The federal government controls nearly 88 percent or 1,273,300 acres of commercial forest land. Private landowners and the states control the remaining 12 percent.

Table III-12.--Area of commercial forest land by ownership classes and states, San Juan River Basin, Arizona, Colorado, New Mexico and Utah - 1969

State	All Ownership	National Forests	BLM	National Parks	Indian Lands	State and Private	Percent
Arizona	98,000	0	0	0	98,000		7
Colorado	919,100	737,100	16,000	0	30,000	136,000	63
New Mexico	317,200	38,000	1,200	0	236,000	42,000	22
Utah	117,000	117,000	0	0	0	0	8
TOTAL	1,451,300	892,100	17,200	0	364,000	178,000	100

Source: U.S. Forest Service.

The commercial forest area is distributed among four major forest types - Douglas fir, Ponderosa pine, spruce-fir, and aspen. The spruce-fir and aspen types grow at high elevations where lands are largely national forest. As a result the Forest Service administers about 85 percent of these types. The ponderosa pine type which grows at relatively low elevations shows a somewhat higher proportion of private-state and other public ownership. Much of the winter range for elk and deer is in this forest type.

Table III-13.--Area of commercial forest land by forest type and ownership, San Juan River Basin in Arizona, Colorado, New Mexico and Utah - 1968

Type	All Owners	National Forests	Other Public	State and Private
	Acres			
Douglas-fir	190,300	160,000	2,300	28,000
Ponderosa pine	724,500	276,000	344,500	104,000
Spruce-fir	344,500	291,000	32,500	21,000
Total Softwoods	1,259,300	727,000	379,300	153,000
Total Hardwoods	192,000	165,000	2,000	25,000
ALL TYPES	1,451,300	892,000	381,300	178,000

Source: U.S. Forest Service

Merchantable wood in growing stock trees in the basin totals about 560 million cubic feet. This volume represents both the base for future timber growth and a supply of standing trees from which timber industries may draw their needs.

Sawtimber volumes total nearly 10 billion boardfeet measured by the International 1/4-inch log rule. Sawtimber stands average about 6,838 boardfeet per acre of commercial forest land. Over 80 percent of this volume is in sawtimber stands. The remainder is in stands of smaller trees. Seventy-six percent of the sawtimber volume is in the national forests, 17 percent in other federal lands, and 7 percent in state and private lands.

Table III-14.--Volume of sawtimber on commercial forest land by ownership by softwood and hardwood, San Juan River Basin in Arizona, Colorado, New Mexico and Utah-1968

Ownership	International 1/4-inch log rule-thousand boardfeet		
	All Species	Softwoods	Hardwoods
National Forest	7,550,772	7,140,272	410,500
Other Public	1,715,090	1,713,231	1,859
State and Private	658,000	581,000	77,000
All Ownerships	9,923,862	9,434,503	489,359

Source: U.S. Forest Service

Softwoods comprise approximately 95 percent of the commercial sawtimber volume and hardwoods only five percent. The spruce-fir type make up almost 52 percent of the total sawtimber volumes, ponderosa pine about 26 percent, Douglas fir 17 percent, and the remainder (5 percent) in hardwoods - primarily, aspen.

Table III-15.--Volume of sawtimber in commercial forest land by species group, San Juan River Basin in Arizona, Colorado, New Mexico, and Utah, 1968

Species	International 1/4-inch log rule thousand boardfeet
Softwoods	
Douglas Fir	1,726,321
Ponderosa Pine	2,557,825
Spruce-Fir	5,150,357
Total ----	9,434,503
Hardwoods	
Aspen	489,359
Total ----	489,359
TOTAL	9,923,862

Source: U.S. Forest Service

The stand-size distribution is quite uniform for the basin. Sawtimber stands make up 71 percent, poletimber stands 15 percent, sapling and seedling stands 3 percent, and nonstocked areas about 11 percent. Approximately one million acres are sawtimber and one-fourth million acres are poletimber.

Table III-16.--Commercial forest land area by stand-size and ownership, San Juan River Basin, Arizona, Colorado, New Mexico and Utah, 1968

Stand-Size Class	All Ownership	Public lands	State and Private
	Acres		
Sawtimber	1,030,000	951,000	79,000
Poletimber	222,000	132,000	90,000
Seedling & Sapling	42,000	33,000	9,000
Nonstocked	157,300	157,300	0
All Classes	1,451,300	1,273,300	178,000

Source: U.S. Forest Service

The 3,930,000 acres of noncommercial forests is primarily the low elevation pinyon-juniper type. Some noncommercial forest land also occurs just below the upper timberline and in small patches on very steep slopes within the commercial forests.

Table III-17.--Area of noncommercial forest land by ownership classes and states, San Juan River Basin in Arizona, Colorado, New Mexico and Utah, 1968

State	All Ownership	National Forests	BLM	National Parks	Indian Lands	State and Private	Percent
Arizona	401,400	0	0	400	401,000	0	10
Colorado	1,277,400	362,000	185,100	38,800	410,500	281,000	33
New Mexico	1,457,300	113,200	389,600	12,600	597,400	344,500	37
Utah	801,900	29,700	355,000	200	254,500	162,500	20
TOTAL	3,938,000	504,900	929,700	52,000	1,663,400	788,000	100

Source: U.S. Forest Service

Although juniper and pinyon are used for fuel, Christmas trees, and fence posts, more ways could be developed to use timber which is now noncommercial.

Many of the older trees, too large for Christmas tree harvest, could be used to make wreaths or other greenery. Dead and fallen timber could be gathered, sawed, and sold for fuelwood. Much of the area occupied by pinyon-juniper is a natural site for tree species with more commercial value. The pinyon-juniper forest type is especially valuable as wildlife habitat. The type provides critical winter range for deer and elk.

WATER RESOURCES

Water Supply

SURFACE WATER

Annual precipitation varies considerably with elevation. Average values range from 50 inches in the high slopes of the San Juan mountains to 6 inches near Mexican Hat and the confluence of the San Juan River with the Colorado River (see Precipitation Map following page III-2). The San Juan River and its principal tributaries, the Navajo, Piedra, Los Pinos (Pine), Animas, and La Plata Rivers, originate in the high slopes of the San Juan mountains. Other tributaries which drain large areas, but contribute little to sustained streamflow are Canyon Carizzo, Canyon Largo, and the Chaco River in New Mexico; Chinle Wash in Arizona; and Montezuma and McElmo Creeks in Utah. Less than 20 percent of the basin area produces over 90 percent of the water supply (see Table III-18 and Figure III-1).

Surface water runoff from melting winter snowpack

SCS PHOTO

High spring runoff months of April through June produce over 56 percent of the stream discharge from the basin (see Figure III-2). This results from melting winter snowpacks which accumulate during October through April.

There is considerable variation of annual discharge over a period of years. This is illustrated by Figure III-3. Flow duration curves shown in Figure III-4 reflect the percent of time that certain discharges could be expected at the indicated locations. For example, a discharge rate of 1,300 c.f.s. is equalled or exceeded 50 percent of the time on the San Juan River near Bluff, Utah whereby, a discharge of 600 c.f.s. is equalled or exceeded 80 percent of the time.

In order to ascertain the amount of water remaining over and above present (1965) uses, there have been reconstructed what are termed present modified flows. The reconstruction of present modified flows was accomplished for the study period 1914 to 1965, the premise being that the general hydrologic conditions of that period might reasonably be expected to reoccur in the future. The 1914-1965 study period was selected as the longest period for which reliable records were generally available in the basin. The procedure is one of adding to the historic annual flows at the outflow point past annual depletions, the result being a virgin annual outflow. Then, assuming that all present uses were in effect throughout the 1914-1965 period, the present (1965) normalized use was deducted from the virgin flow, the result being the present modified flow.

The virgin water supply[2/] near Bluff, Utah averaged about 2,158,500 acre-feet annually for the period 1914-65. This includes an average of 100,700 acre-feet imported yearly from the Dolores River Basin for use in the San Juan Basin. The 1965 modified flow of the San Juan River was estimated at nearly 1,891,700 acre-feet for the same period. The water resources, supply and use, are diagramed on Frontispiece 1.

Surface runoff is the major component of the water supply and accounts for 98 percent of the water used. There is, however, a substantial amount of ground water in storage in the San Juan Basin. The distribution of ground water is such as to make recovery in large quantities economically impractical at most places.

2/ Undepleted modified water supply as used herein, indicated the aggregate natural runoff prior to man-related depletions.

Headwaters of the San Juan River, Colorado

SCS PHOTO

Table III-18.--Streamflow in the San Juan Basin

Station No.	Station	Drainage Area (sq mi)	Avg. Water discharge[1] 1914-1957		Avg. Water Discharge 1914-1965	
			Average (cfs)	Average annual (acre-ft)	Historical Average Annual (Acre-ft)	1965 Modified Average Annual (Acre ft)
		San Juan River Basin				
3400	San Juan River near Pagosa Springs, Colo	86.9	135	97,800	94,700[3]	
3405	West Fork San Juan River above Borns Lake, near Pagosa Springs, Colo	41.2	88.5	64,110		
3425	San Juan River at Pagosa Springs, Colo	298	403	292,000		
3460	Navajo River at Edith, Colo	165	164	118,800		
3460B	San Juan River near Arboles, Colo	1,340	748	541,900		
3495	Piedra River near Piedra, Colo	371	380	275,300		
3505	San Juan River at Rosa, N. Mex.	1,990	1,208	875,100	849,800[3]	
3535	Los Pinos River near Bayfield, Colo	284	397	287,600		
3545	Los Pinos River at La Boca, Colo	510	278	201,400		
3550	Spring Creek at La Boca, Colo	58	35.3	25,570		
3565	San Juan River near Blanco, N. Mex.	3,560	1,519	1,100,000		
3575	Animas River at Howardsville, Colo	55.9	117	84,760		
3590	Mineral Creek near Siverton, Colo	43.9	105	76,070		
3610	Hermosa Creek near Hermosa, Colo	172	147	106,500		
3615	Animas River at Durango, Colo	692	859	622,300	608,200[3]	
3645	Animas River at Farmington, N. Mex.	1,360	971	703,500		
3655	La Plata River at Hesperus, Colo	37	48.3	34,990		
3665	La Plata River at Colorado-New Mexico State line	331	38.5	27,800		
3675	La Plata River near Farmington, N. Mex.	583	31.4	22,750		
3680	San Juan River at Shiprock, N. Mex.	12,900	2,679	1,941,000	1,876,300[2]	1,830,300[3]

Table III-18.--(Contd), Streamflow in the San Juan Basin

Station No.	Station	(sq mi)	(cfs)	(acre-ft)	(Acre-ft)	(Acre-ft)
3710	Mancos River near Towaoc, Colo	550	62.4	45,210		
3715	McElmo Creek near Cortez, Colo	233	53.5	38,760		
3795	San Juan River near Bluff, Utah	23,000	2,800	2,028,000	1,955,000 2/	1,891,700 3/

1/ Source - Water Resources of the Upper Colorado River Basin - Basic Data, U.S.G.S. Professional Paper 441, 1964, by W. V. Iorns, et al.

2/ Source - Upper Colorado Region Comprehensive Framework Study, Appen. V, Water Resources

3/ Source - USDA River Basin Staff, Data adjusted to 1965 conditions.

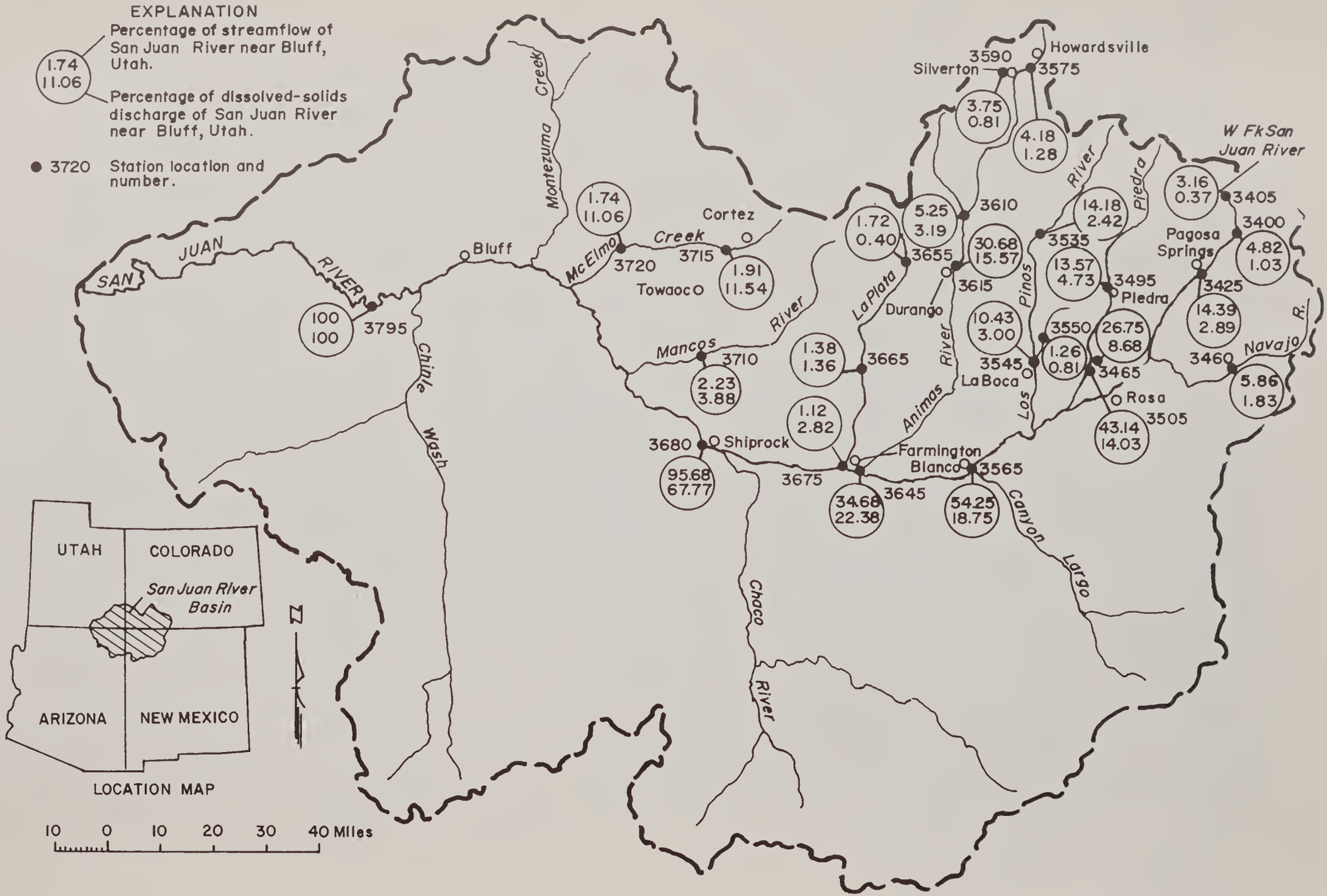


Fig. III-1. Approximate streamflow expressed as percentages of the streamflow of San Juan River near Bluff, Utah.
Source: USGS Professional Paper 441

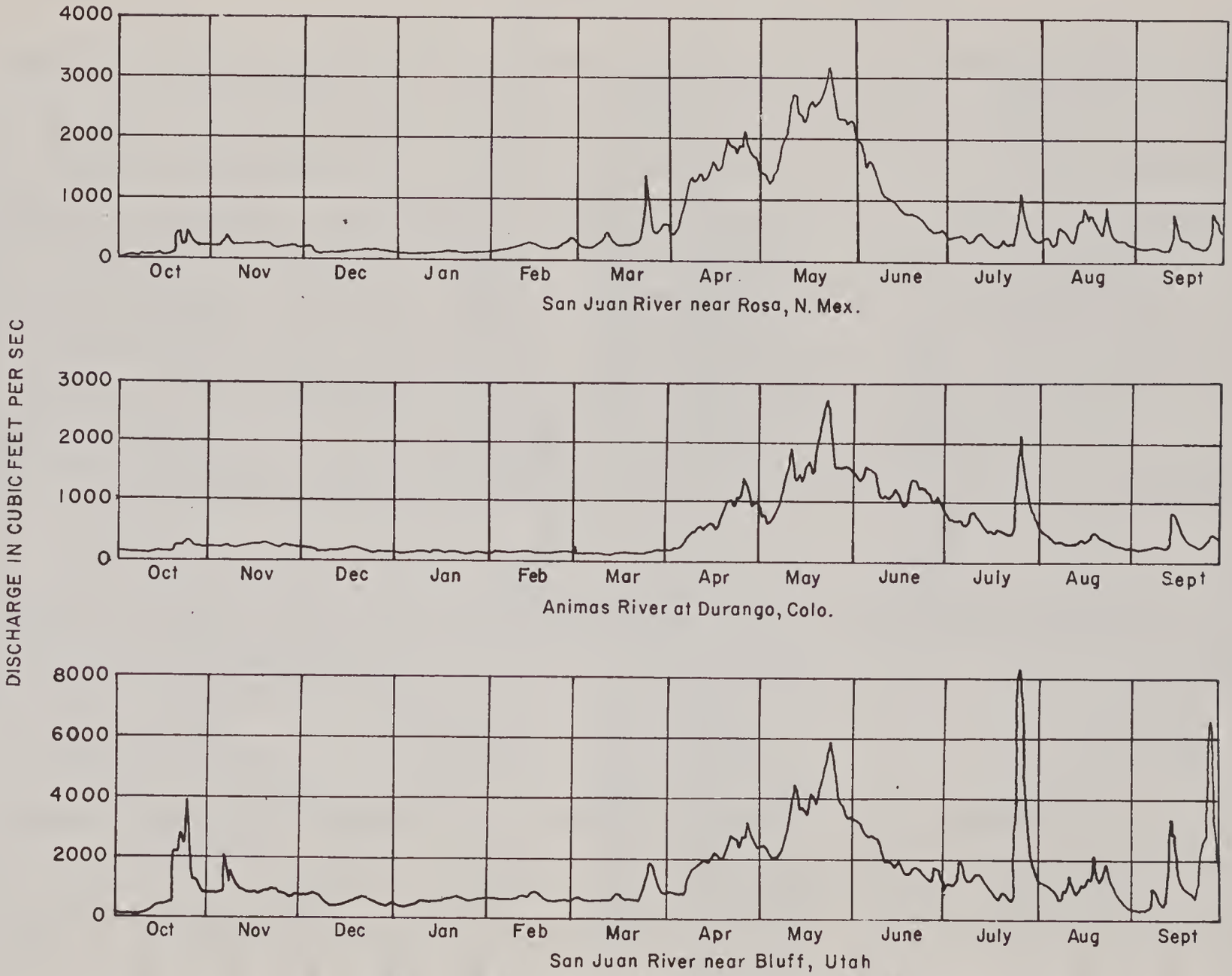


Figure III-2. -Seasonal pattern of runoff of streams in the San Juan River Basin, 1954 water year. Source: USGS Professional Paper 441

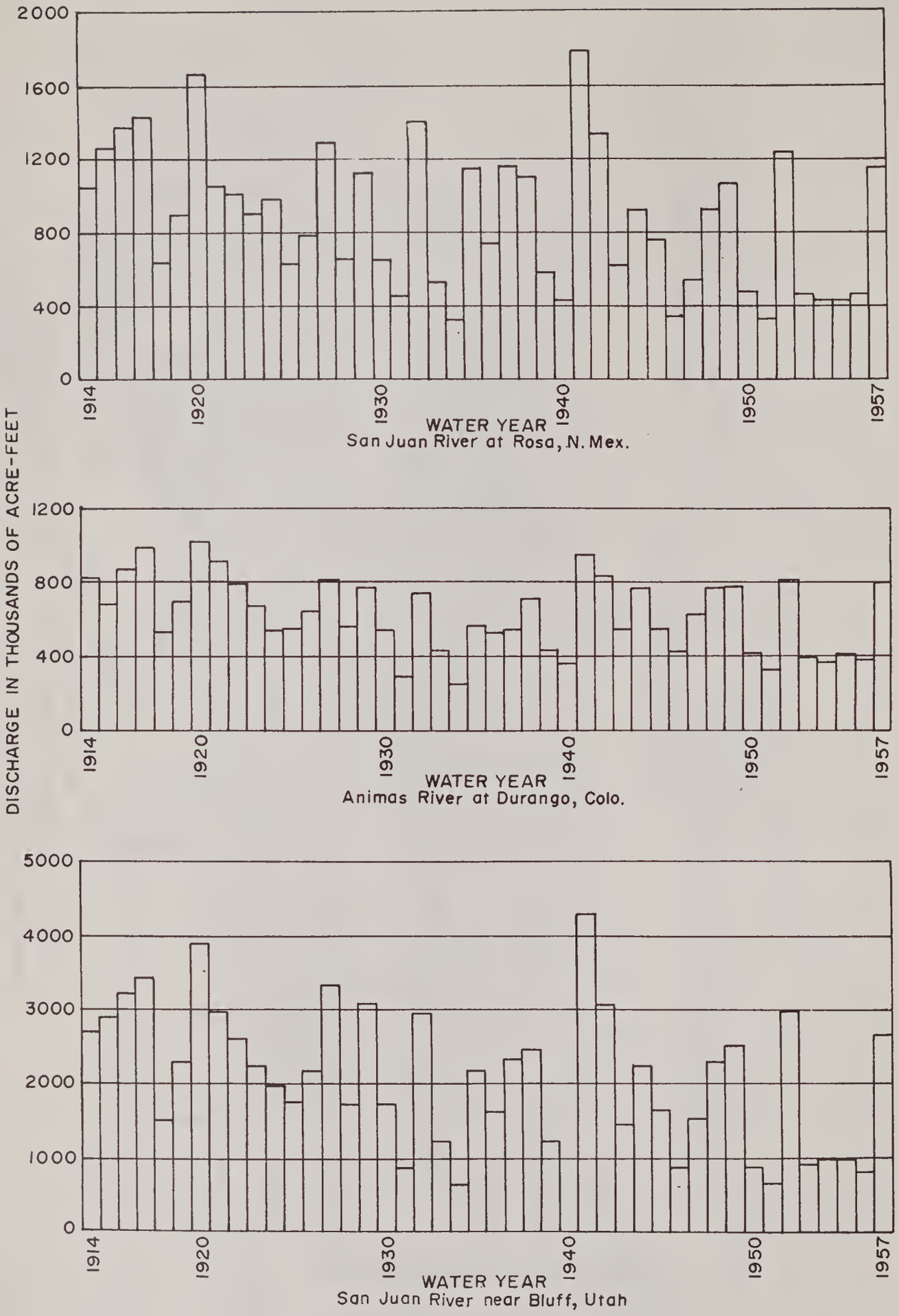


Fig. III-3. Variability of annual discharges of streams in the San Juan River Basin, water years 1914-57.

Source: USGS Professional Paper 441.

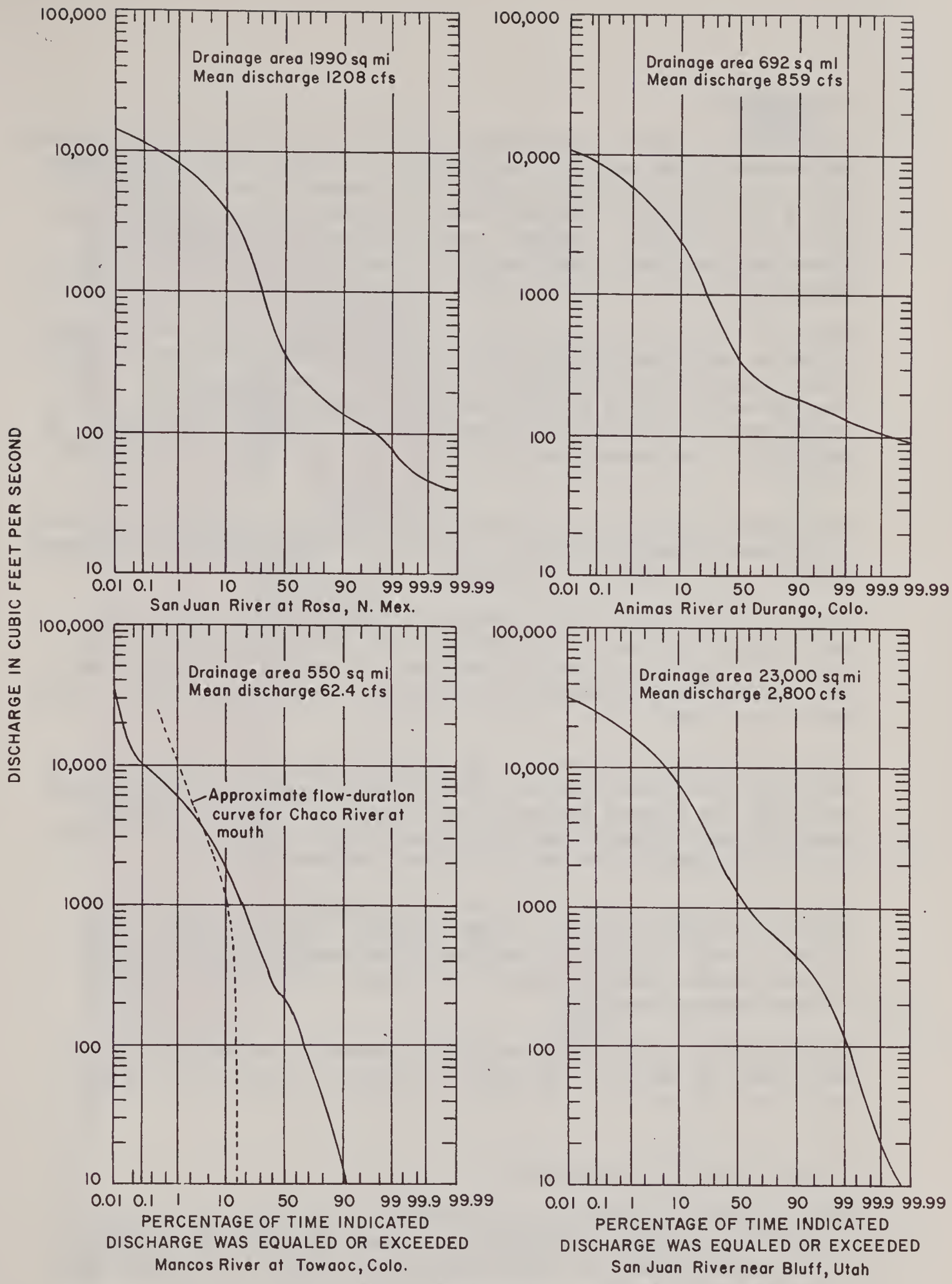


Fig. III-4 Flow-duration curves of streams in the San Juan River Basin, water years 1914-57 adjusted to 1957 conditions.

Source: USGS Professional Paper 441

GROUND WATER

Both the availability and chemical quality of ground water are greatly influenced by the geology. In general, the older consolidated rocks yield water slowly to wells and springs, whereas sand and gravel strata in the younger unconsolidated deposits and some igneous rocks yield water readily. However, even the oldest consolidated rocks, where they have been fractured by structural deformation or honeycombed by solution activity, yield water readily to wells and springs.

Rocks that have their origin in brackish water or marine environments and have low permeability, such as shales and some limestones, siltstones generally yield water of the poorest chemical quality. Alluvium generally yields water of the best chemical quality, but the ground water in some alluvial aquifers may be highly saline owing to hydrologic interconnections with rocks that normally contain saline water.

The general availability of ground water to individual wells is shown on the map following this page. This map is based in part on records of wells and in part on the geology.

Yields to individual wells generally range from 5 to 50 gpm over a major portion of the basin. Yields of 50-500 gpm can be expected from wells that tap alluvium along some of the major streams. Most wells along these streams for which records are available have yields nearer the lower limit.

The depth to ground water is a factor affecting general availability and particularly the cost and feasibility of pumping. The following map shows the general depths to water levels. Levels are deepest, generally more than 500 and locally more than 1,000 feet below land surface adjacent to the deeply incised San Juan River.

Data in the mountainous areas and high plateaus are inadequate to determine depths to water. Depths to water levels in these areas probably range from only a few feet below land surface along most stream channels to more than 500 feet below land surface near the divides between streams.

The following map shows the estimated volume of recoverable ground water that is stored in the upper 100 feet of saturated rocks per square mile area.

Existing Reservoirs and Lakes

Slightly more than 100 existing reservoirs and lakes are listed in Table III-19. There are undoubtedly others that are not included in the table because of insufficient data, however, they would not be major impoundments.

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LOCATION MAP

The map is based on well records collected by the U.S. Geological Survey and cooperating State, local, and other Federal agencies. In areas where hydrologic data are inadequate or lacking, potential yields are inferred from geologic data. The map does not indicate the total quantity of water that can be safely developed in any given area or ground water reservoir. These determinations generally can be made only on the basis of special investigations. The map is intended only as a convenient guide to the general availability of ground water throughout the basin. More detailed information for specific parts of the basin are obtainable from the district offices of the Water Resources Division, U.S. Geological Survey, in Tucson, Ariz.; Denver, Colo.; Albuquerque, N. Mex.; Salt Lake City, Utah; and Cheyenne, Wyo.

LEGEND

Areas where properly located and constructed, wells are generally capable of yielding quantities of water within the limits given below.

Gallons per minute

- 1-10
- 5-50
- 5-50 (Some wells yield 50 to more than 500)
- 50-500 (Some wells yield 500 to more than 1,000)

GENERAL AVAILABILITY OF GROUND WATER

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

DECEMBER 1972

10 0 10 20 MILES

SCALE 1:1,150,000

Source: Upper Colorodo Region, Comprehensive Framework Study, Appendix V.

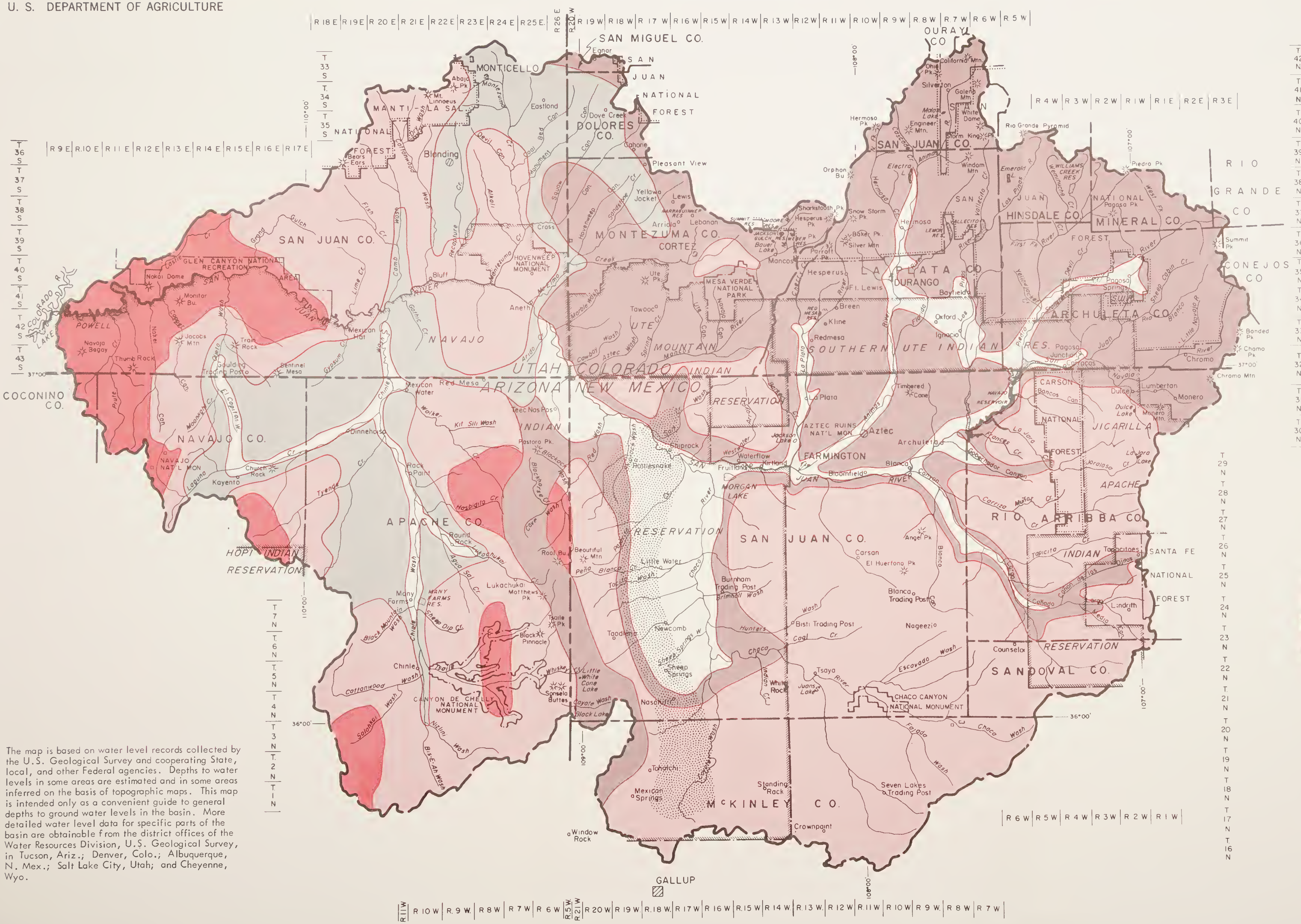
M7-N-22573C

USDA SCS PORTLAND OREGON 1972

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LOCATION MAP



LEGEND

Areas where depths to ground water levels generally are within the limits given below.

Feet below land surface

- 50–100 (Generally less than 50 along stream bottoms)
- 100–200
- 200–500
- 500–1,000 (More than 1,000 locally)
- Less than 50 to more than 500 (Generally less than 50 along stream bottoms to more than 500 on plateaus and near stream divides)
- Artesian areas where some wells flow at land surface

The map is based on water level records collected by the U.S. Geological Survey and cooperating State, local, and other Federal agencies. Depths to water levels in some areas are estimated and in some areas inferred on the basis of topographic maps. This map is intended only as a convenient guide to general depths to ground water levels in the basin. More detailed water level data for specific parts of the basin are obtainable from the district offices of the Water Resources Division, U.S. Geological Survey, in Tucson, Ariz.; Denver, Colo.; Albuquerque, N. Mex.; Salt Lake City, Utah; and Cheyenne, Wyo.

GENERAL DEPTH TO GROUND WATER LEVELS

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

DECEMBER 1972

10 0 10 20 MILES
SCALE 1:1,150,000

Source: Upper Colorado Region, Comprehensive Framework Study, Appendix V.

USDA SCS PORTLAND OREGON 1972

M7-N-22573B

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LOCATION MAP

The map is based entirely on estimated specific yields of the various rock types in which water occurs. The figures are intended only as a convenient index to the relative volumes of ultimately recoverable ground water in storage. Where potential recharge is small, the quantity of recoverable water may be less than that shown; where potential recharge is large, the quantity recoverable may be larger than that shown. Also, the map was compiled without regard to chemical quality of ground water. Determinations of quantity and quality of water that can be developed in any given area can be made only on the basis of more detailed investigations. Additional data in some parts of the basin are obtainable from the district offices of the Water Resources Division, U.S. Geological Survey, in Tucson, Ariz.; Denver, Colo.; Albuquerque, N. Mex.; Salt Lake City, Utah; and Cheyenne, Wyo.

LEGEND

Areas where the volume of recoverable ground water in the upper 100 feet of saturated rocks would be within the limits given below.

Thousands of acre-feet per square mile

- 1.3 to 3.2 (Mostly volcanic rocks)
- 0.6 to 1.3 (Mostly sandstone)
- 0.3 to 0.6 (Mostly siltstone, shale and limestone)
- 0 to 0.3 (Mostly shale and crystalline rocks)

ESTIMATED QUANTITY OF GROUND WATER
Stored in the upper 100 feet of saturated rocks

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

DECEMBER 1972

10 0 10 20 MILES

SCALE 1:1,150,000

Source: Upper Colorado Region, Comprehensive Framework Study, Appendix V.

USDA-SCS PORTLAND, OREGON 1972

M7-N-22573D

Navajo Dam and Reservoir, New Mexico
SCS PHOTO

Approximately 78 of the listed impoundments have irrigation as the major use with a total useable storage capacity of 1.8 million acre-feet. About 85 percent of this useable storage is included in the Navajo Reservoir which controls 3,230 square miles of the San Juan River drainage.

Included in Table III-19 are 14 impoundments used primarily for municipal water and 24 listed as fish and wildlife measures. Useable storage capacity data was not available for most of these impoundments, however, it would be minor in relation to irrigation reservoir storage. Their combined surface area totals approximately 1,300 acres.

Table III-19.--Existing reservoirs and lakes by state, San Juan River Basin, 1972

Reservoir Name	Drainage	Purpose 1/	Usable Capacity (Acre-feet)	Maximum Surface Area (Acres)
Arizona				
Many Farms	Chinle Wash	I	25,000	1,200
Lower Rock Point	Chinle Wash	"	1,000	
Marsh Pass	Chinle Wash	"	1,160	
Round Rock Lake	Lukachukai Wash	"		
Pinnacle Lake		"		
Tsaile Lake	Tsaile Creek	F&W		5
Wheatfields Lake	Chinle Wash	"		272
Colorado				
Bauer Lake No. 1	Mancos River	I	320	26
Bauer Lake No. 2	Mancos River	"	1,530	100
Columbine Lake	Animas River	"	340	35
Ducks West			1,219	139
Electra Lake	Animas River	"	22,000	839
Echo Creek Canyon	San Juan River	"	750	118
Emerald Lake	Los Pinos River	"	1,770	356
Hatcher	Piedra River	"	1,735	134
Pastoris	Animas River	"	200	48
Red Mesa	La Plata River	"	1,176	133
Sullenberger	Peora River	"	200	24
Stevens	Piedra River	"	634	87
Totten	Mancos River	"	3,300	234
Turner	Animas River	"	500	50
Weber	Mancos River	"	259	40
Williams Creek	Piedra River	"	10,000	266
Colorado				
Jackson Gulch	Mancos River	I	9,840	218
Lemon	Florida River	"	39,000	620
Vallecito	Los Pinos River	"	126,280	2,723

Table III-19. (contd)

State/Reservoir Name	Drainage	1/ Purpose	Useable Capacity (Ac.Ft)	Maximum Surface Area (Acres)
Colorado				
Andrews Lake		F&W		20
Capate Lake		"		52
Cataract Lake		"		40
Durango Hatchery	Animas R.	"		3
Haviland Lake		"		70
Henderson Lake		"		11
Lost Lake		"		10
Ute Mountain (3 res.)	Mancos R.	"		6
City (Durango)	Animas R.	M&I		100
Bayfield	Los Pinos	"		4
Mancos	Mancos R.	"		30
4 Ponds	Mancos	"		9
New Mexico				
Black Lake	Coyote Wash	I,R	900	85
Chuska Lake	Red Willow Cr.	"	1600	155
Deadman Lake	Wheatfield Cr.	"	1100	100
Dulce Lake	Dulce Canyon	"	1000	104
Juan's Lake	Chaco Canyon	"		40
Long Lake	Red Willow Cr.	"	8000	350
Lost Lake	Coyote Wash	"	600	45
Lower Mundo Res.	Mundo Canyon	"		64
Morgan Lake	San Juan R	M&I,R	45000	1200
Whiskey Lake	Red Willow Cr.	I,R	4500	250
Navajo	San Juan R.	M&I	1696000	15600
Beeline (Farmington 3)	Animas R.	"		200
Farmington	"	"		10
Aztec	"			2
Bass Lake		R		5
Butler Lake		R,M&I		10
Berland Lake		R		7
Big Gap Lake		"		15
Bolack Lake		I,R		36
Captain Tom's Lake	Captain Tom Wash	R		100
Holmburg Lake		"		2
Jackson Lake	LaPlata R.	"		69
LaJara Lake	LaJara Canyon	"		58
Little White Cone Lake	Little Whiskey Creek	"		40
Mulholand		"		4
Toadacheene Lake		"		10
Ferris				9
Crowley				20
Luna Lake		"		30
El Paso Lakes		I, M&I		6
Southern Naschitti				3

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

DISSOLVED SOLIDS IN STREAMS
SAN JUAN RIVER BASIN
ARIZONA, COLORADO, NEW MEXICO AND UTAH

NOVEMBER 1972

LOCATION MAP

LEGEND

Approximate weighted-average concentration, in milligrams per liter

- Less than 100
- 101-250
- 251-500
- 501-1,000
- 1,000-2,000
- 2,000-3,000

In areas where there ore few or no chemical-quality sampling sites, the weighted-average concentration of dissolved solids were estimated from data observed in adjacent areas of similar geology and topography. Data from these areas of few or no sampling sites should be used with discretion.

SCALE 1:1,130,000

10 0 10 20 MILES

"Source – Upper Colorado Region Comprehensive Framework Study, Appendix XV"

USDA SCS PORTLAND OREGON 1972

M7-N-22573F

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LOCATION MAP

LEGEND

Areas where properly located and constructed, wells yield water with concentrations of dissolved solids generally within the limits given below

Milligrams per liter

- Less than 500 (Less than 250 in some mountainous areas)
- 500-1,000
- 1,000-3,000
- More than 3,000
- 250-1,000
- 500-3,000 (More than 3,000 locally)

The map is based mainly on quality-of-water data collected by the U.S. Geological Survey and cooperating State, local, and other Federal agencies. In areas where data are inadequate or lacking, the limits of dissolved solids are inferred from geologic data. Dissolved solids in water produced from depths greater than 1,000 feet generally ranges from 1,000 to more than 10,000 mg/l, but some zones contain water with less than 1,000 mg/l. The map is intended as a convenient guide to the general chemical quality of ground water throughout the basin. Determination of the chemical quality of ground water in any given part of the basin can be made only on the basis of special investigations. More detailed information on the chemical quality of ground water in specific areas is obtainable from the district offices of the Water Resources Division, U.S. Geological Survey, in Tucson, Ariz.; Denver, Colo.; Albuquerque, N. Mex.; and Salt Lake City, Utah.

DISSOLVED SOLIDS IN GROUND WATER

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

NOVEMBER 1972

10 0 10 20 MILES

SCALE 1:1,150,000

"Source – Upper Colorado Region Comprehensive Framework Study, Appendix XV"

USDA-SCS-PORTLAND OREGON 1972

M7-N-22573G

Table III-20.--Water discharge and dissolved solids, San Juan River Basin (data are for the water years 1914-57 adjusted to 1957 conditions)

Measuring Station	Drainage Area (Sq.Mi.)	Water Discharge: Average (CFS)	Water Discharge: Average Annual (Acre-ft)	Dissolved Solids: Weighted-Average Concentration (PPM)	Dissolved Solids: Average Discharge (Tons Per Day)	Dissolved Solids: Average Annual Yield Per Sq. Mi. (Tons)	Dissolved Solids: Average Annual Discharge (Tons)
San Juan River near Pagosa Springs, Colorado	86.9	135	97,800	77	28	118	10,230
West Fork San Juan River above Borns Lake, near Pagosa Springs, Colorado	41.2	88.5	64,110	42	10	89	3,650
San Juan River at Pagosa Springs, Colorado	298	403	292,000	73	79	97	28,850
Navajo River at Edith, Colorado	165	164	118,800	113	50	111	18,260
San Juan River near Arboles, Colorado	1,340	748	541,900	104	211	57	77,000
Piedra River near Piedra, Colorado	371	380	275,300	126	129	127	47,120
San Juan River at Rosa, New Mexico	1,990	1,208	875,100	117	383	70	139,900
Los Pinos River near Bayfield, Colorado	284	397	287,600	62	66	85	24,110
Los Pinos River at La Baca, Colorado	510	278	201,400	108	81	58	29,590
Spring Creek at La Baca, Colorado	58	35.3	25,570	231	22	139	8,040
San Juan River near Blanca, New Mexico	3,560	1,519	1,100,000	125	512	53	187,000
Animas River at Howardsville, Colorado	55.9	117	84,760	111	35	229	12,780
Mineral Creek near Silverton, Colorado	43.9	105	76,070	78	22	183	8,040
Hermosa Creek near Hermosa, Colorado	172	147	106,500	219	87	185	31,780
Animas River at Durango, Colorado	692	859	622,300	183	425	224	155,200
Animas River at Farmington, New Mexico	1,360	971	703,500	233	611	164	223,200
La Plata River at Hesperus, Colorado	37	48.3	34,990	84	11	109	4,020
La Plata River at Colorado-New Mexico State line	331	38.5	27,890	356	37	41	13,510
La Plata River near Farmington, New Mexico	583	31.4	22,750	908	77	48	28,120
San Juan River at Shiprock, New Mexico	12,900	2,679	1,941,000	256	1,850	52	675,700
Mancos River near Towaoc, Colorado	550	62.4	45,210	629	106	70	38,720
McElmo Creek near Cortez, Colorado	233	53.5	38,760	2,180	315	494	115,100
San Juan River near Bluff, Utah	23,000	2,800	2,028,000	361	2,730	43	997,100

Source: Geological Survey Professional Paper 441.

categories of use; irrigated crops and related incidental use, municipal and industrial, electric power, minerals, augmented fish and wildlife, recreation, and basin export. Data pertaining to these specific uses are shown in Table III-21.

Water depletions related to irrigated land which includes plant consumptive use, incidental use and reservoir evaporation amounts to 89 percent of the total depletions related to man's activities.

Water depletions for municipal and industrial purposes totaled 15,800 acre-feet (4.3 percent of total depletions) for the 1965 level of development. The M&I segment of depletion consisered here includes: domestic, manufacturing, livestock, governmental, commercial and other minor related uses.

Lake Morgan, cooling pond for the Four Corners thermal-electric power plant SCS PHOTO

It was estimated that electric power generating facilities depleted the basin water supply by 15,300 acre-feet (4.2 percent of total depletions) in 1965. This use is related to thermal rather than hydroelectric plants because little actual depletion occurs from hydroelectric power generation other than evaporation from cooling pond facilities.

Table III-21--Present water use, 1965, San Juan River Basin

Type of Use	Colorado	New Mexico	Arizona	Utah	Basin Total
	Ac-Ft	Ac-Ft	Ac-Ft	Ac-Ft	Ac-Ft
Irrigated Crops					
Consumptive Use 1/	170,200	76,000	4,300	5,500	256,000
Reservoir Evaporation	8,700	31,700	2,000	100	42,500
Incidental Use 2/	12,000	15,000	500	1,300	28,000
	190,900	122,700	6,800	6,900	327,300
M&I 3/	7,500	4,800	1,700	1,800	15,800
Electric power 3/		15,300			15,300
Minerals 3/	1,900	1,600		1,100	4,600
Augmented Fish and Wildlife 3/	700	400	600	100	1,800
Recreation 3/	100	100			200
Export	2,500				2,500
Total	203,600	144,900	9,100	9,900	367,500

1/ Irrigated acreage: Colorado=168,300 ac., New Mexico=44,800 ac., Arizona= 4,600 ac., Utah=5,000 ac.; Total idle = 34,100.

2/ Incidental use of irrigation water by phreatophytes and other miscellaneous vegetation.

3/ Includes evaporation losses applicable to these sources of depletion.

Source: Upper Colorado Region Comprehensive Framework Study

Water depletion by mining industry totaled 4,600 acre-feet in 1965 or 1.2 percent of the total man-related depletions. Augmented fish and wildlife and recreation depletions combined amount to about 0.6 percent or 2,000 acre-feet.

Several small ditches divert water from the headwaters of the San Juan River in Colorado to the Rio Grande Basin in Colorado. The first of these diversions began in 1923. It was estimated that for 1965 conditions approximately 2,500 acre-feet was exported from the basin (0.7 percent of total depletions.)

By far the greatest depletion from the basin's gross water supply is evapotranspiration from native vegetation which, for the most part, is unrelated to man's activities. The extent of this segment of depletion has not been determined herein.

FISH AND WILDLIFE RESOURCES

Fish and wildlife are important to both the economy and the environment of the basin. Because of low human population and large areas of public land, the fish and wildlife resources are relatively abundant. Fishing, hunting, and nonconsumptive uses are major outdoor activities of both residents and visitors. Opportunities for the public to participate i- these activities are available throughout the Basin.

Fish Resources

Sport fishing, historically restricted to free flowing streams and natural lakes, has changed radically. With the exception of some remote lakes high in the mountains, most natural lakes have been modified for additional water storage or control. Many of the streams have been modified or diverted for flood control, irrigation, and municipal and industrial uses.

Much of the present day sport fishing occurs in man-made reservoirs. The area of reservoir water far exceeds that of natural lakes. The tailwaters below regulatory dams on major rivers provides some stream fishing but, in general, the stream fishery resource has been diminished by uses of water for out-of-stream purposes.

The game fish themselves have changed. Cutthroat trout and mountain white fish are the only native game fish species. They have been supplemented and in some cases, supplanted, by introduced fish species. Rainbow trout, a native of the Pacific Northwest, has been widely introduced. Because they are easily propagated in hatcheries, tremendous numbers of rainbow trout are stocked annually. They have replaced the native cutthroat trout in most of the natural lakes and

many streams. The Eastern brook trout (char) and European brown trout have also been introduced, in many cases providing a new fishery resource since they occupy habitats not suitable for native game fish.

Warm water fish have been stocked in low elevation waters and many man-made ponds and reservoirs; channel catfish have been especially successful in streams. Largemouth bass, pike and walleye, are important species in large reservoirs such as Lake Powell and Navajo Reservoir. Farm ponds and reservoirs have been stocked with bluegills and crappie.

Game Resources

Mule deer and elk are the primary game animals. Deer occur throughout the basin and provide the greatest hunting opportunity. Elk occupy extensive areas of the Colorado portion of the basin. Utah and New Mexico have small populations, but important areas of winter habitat for migratory herds are found in these states. Arizona has no elk within the basin. The Colorado elk population is quite large and the area is nationally important for the hunting opportunity provided. Other important game animals include wild turkeys which have been reintroduced to large areas of suitable habitat, bighorn sheep, black bears, and a variety of small game and game birds.

All species of wildlife, non-game as well as game animals, contribute to human enjoyment. These animals provide opportunity for observation, photography, and scientific study. They are essential components of the high quality natural environment of the basin.

WATER RIGHTS AND COMPACTS

State of Arizona

ACQUISITION, ADJUDICATION & ADMINISTRATION OF WATER RIGHTS

Long before Arizona became a state, the territorial courts had held, in effect, that the common law doctrine of Riparian water rights did not apply in Arizona and that the doctrine of prior appropriation applied to surface waters. There were no formalities required in initiating or in completing these early appropriative rights. In 1893, the Arizona territorial legislature prescribed that any person desiring to appropriate water must post notice at the point of diversion stating the amount of water appropriated, the character of the works to be constructed, and that such works would be completed within a reasonable time.

The Arizona Constitution provides specifically that the common law doctrine of Riparian water rights shall not obtain or be of any force or effect in Arizona.

In 1919, the Arizona Water Code was adopted. Among other things, this code prescribed procedures for the acquisition of surface water rights. The authority for administration of the Arizona Code originally existed in a water commissioner, but has since been vested in the office of the State Land Commissioner. This Code has been amended many times and has been tested and interpreted by the courts establishing numerous precedents.

The concept of waters being vested with a character of public property, and being subject to appropriation, appears to have been the prime factor of Arizona water law. The doctrine of prior appropriation, as it is commonly known, bases the right to the use of water upon the application of that water to some beneficial purpose. This right is dependent upon the demonstration that the water is applied to a beneficial use and is irrespective of location of the land where the water is applied.

Water rights in stream water do not in any way depend on ownership of land bordering on a stream or land through which a stream may run. Since the valid water rights depend soley upon use, the water may be transported to land or to an area far removed from a stream for this use, even into an entirely different watershed.

The right to stream water or surface water also depends on the time at which the water was diverted for its beneficial purpose. A water right is valid only when it does not interfere with, or damage, the right of another who has a prior claim to the same water. He who first diverts water for beneficial use has the better right, and other rights of subsequent appropriators are subject to his. In case of a shortage of water, the latest appropriators are required to relinquish their water to the prior appropriators in order that the latter's claim may be fully satisfied. The maxim *first in time, first in right* is an accurate translation of this doctrine.

One has a right only to that amount of water that can, and is, being used beneficially. This is clear under this doctrine that all water is to be used and none is to be wasted. There is no intention to maintain the flow of water in the stream. Every available drop can be utilized, even to the extent of drying up the stream itself. Surplus waters are subject to appropriation. If one fails over a period of time to use water to which he has laid claim, he loses his water right and another may appropriate that water.

The following excerpt is taken from Article I of the Arizona State Water Code: *The water of all sources, flowing in streams, canyons, ravines, or other natural channels, or in definite underground channels, whether ponds and springs on the surface, belongs to the public, and is subject to appropriation and beneficial use . . . . Beneficial use shall be the basis, measure and limit to the use of water. Whenever the owner of a right to the use of water shall cease or fail to use the water appropriated for five (5) successive years, the right to the use shall cease, and the water shall revert to the public and be again subject to appropriation.*

The Arizona Revised Statutes pertaining to surface water law were amended in 1962 by Senate Bill No. 39. This bill listed the rights of the state in appropriation of water. It covers severance and transfer of water rights appurtenant to cropland for municipal, stock watering, power and mining, and recreation and wildlife purposes (including fish) under specified conditions and limitatijons. Consent and approval by all interested parties must be agreed upon before any transfer of water rights may be approved.

Another amendment enacted under Senate Bill No. 39 during 1962 read as follows: *As between two or more pending conflicting applications for the use of water from a given water supply, when the capacity of the supply is not sufficient for all applications, preference shall be given by the department according to the relative values to the public of the proposed use.*

The relative values to the public for the purposes of this section shall be:

1. *Domestic and municipal uses. (Domestic uses shall include gardens not exceeding one-half acre to each family.)*

2. *Irrigation and stock watering.*

3. *Power and mining uses.*

4. *Recreation and wildlife, including fish.*

Unlike the more settled nature of the surface water law, concern for ground water conservation in Arizona continued to mount during the 1930's until the legislature finally directed the State Land Commissioner in 1939 to gather information for future ground water legislation. The result of the action was the passage of the Ground Water Act of 1945, which merely required owners and operators to report, to the State Land Commissioner, data pertaining to their wells and notice of intent before drilling new wells. Although the Act did make the first attempt to provide information about the rate of depletion, it did nothing to lessen or control the excess pumping.

The Arizona Supreme Court had repeatedly stated, from early territorial court opinions in 1904 through a final decision in 1953, that percolating waters belong to the surface landowner and may not be appropriated. Thus, the foundation of Arizona's Ground Water Law was established from court precedents and is based on the distinction that *waters percolating generally through soil beneath the surface are the property of the owner of the soil* and *subterranean streams flowing in natural channels between well-defined banks, are subject to appropriation under the same rule as surface water streams* (8 Arizona 353).

On April 1, 1948 the Arizona Legislature enacted the first ground water code, which was presumably pursuant to the information so acquired from the 1945 Act. This code is found in Sections 45-301 through 45-324 of the Revised Statutes, 1956. The code did not abolish the law with respect to the ownership of the ground water or the rules of reasonable use, which remains the basic law of Arizona.

The most notable accomplishment of the code, in addition to the designation of the rules and regulations for the administration of ground water development, was the establishment of procedures for the designation of critical ground water areas. A *critical ground water area* is defined by statute, as any ground water basin (which is also defined by statute) or any designated subdivision thereof, not having sufficient ground water to provide a reasonably safe supply for irrigation of the cultivated lands in the gasin at the then current rates of withdrawal. The code further provided that, after the determination concerning the overlying lands within such a critical ground water area declared, the drilling of additional irrigation wells was prohibited. The code does not provide, however, for control or apportionment of the existing uses of ground water among the landowners within the designated critical ground water area.

In Southwest Engineering Company vs. Ernst, 79 Ariz. 403 (1955), the court said: *It should be emphasized that in critical areas the Act does not purport to regulate the use of ground water between owners of land in cultivation, nor does it regulate the use of ground water outside of critical areas with the exception that waste as defined is universally prohibited.* That case held that the code was a valid conservation measure enacted under the police power. Its primary purpose is to regulate the pumping and use of water for irrigation in critical areas in an attempt to slow down the exhaustion of ground water.

Another purpose is to require the State Land Department to gather information regarding ground water basins, their location, extent and depletion. The statutue does, in some instances, however, curtail the freedom of the overlying owner to use his property as he sees fit.

Section 45-301 defines certain terms, in part, as follows:

In this article, unless the context otherwise requires:

1. *Critical ground water area means any groundwater basin or any designated subdivision thereof, not having sufficient ground water to provide a reasonably safe supply for the irrigation of the cultivated lands in the basin at the then current rates of withdrawal.*

3. *Exempted well means a well or other works for the withdrawal of ground water used for domestic, stock watering, domestic water utility, industrial or transportation purposes . . . .*

5. *Ground water basin means land overlying, as nearly as may be determined by known facts, a distinct body of ground water . . . .*

6. *Ground water subdivision means an area of land overlying . . . a distinct body of ground water. It may consist of any determinable part of a ground water basin . . . .*

8. *Irrigation well means any well or works for the withdrawal of ground water primarily used for irrigation purposes and having a capacity in excess of one hundred gallons per minute.*

14. *Well means only those wells used for irrigation or drainage and having a capacity of more than one hundred gallons of water per minute.*

The term *a reasonably safe supply* has not yet been construed or defined by the State Supreme Court or by an administrative regulation. In view of the legislative purpose, a ground water basin or a subdivision thereof is probably considered as no longer having *a reasonably safe supply* for irrigation, and is therefore, a critical ground water area when the total annual withdrawal, from both irrigation and exempted wells, exceeds the annual recharge.

State of Colorado

ACQUISITION, ADJUDICATION & ADMINISTRATION OF WATER RIGHTS

The Colorado Doctrine of Prior Appropriation was adopted in the state of Colorado in the very early irrigation days. The Colorado Doctrine as set forth in the State Constitution, adopted in 1876, and judicial decisions state that: *(1) water in its natural course is the property of the public, and is not subject to private ownership; (2) a vested right to use the water may be acquired by appropriation and application to beneficial use; (3) the person first in time to use the water is first in right; and*

(4) beneficial use is the basis, the measure and the limit of the right.

An appropriation is accomplished by the actual diversion of water from a natural watercourse, followed within a reasonable time thereafter by the application of such water to a beneficial use. An important condition of the rule is that the initiation of the appropriation must be followed by the diligent construction of the necessary works and the application of the water to beneficial use. If due diligence is proven, the date of priority reverts back to the initiation of the work, usually the date of the making of the initial survey.

The Colorado Constitution sets up an order of preferential use as follows: (1) domestic, (2) irrigation, and (3) industrial. This preference for certain uses must not be confused with priorities. A preferred use does not thereby automatically obtain a senior priority. The only practical effect of the preference is to give a preferred use the right to condemn a subordinate use. As an example, on occasions, municipalities have obtained water rights covered by irrigation priorities through the use of the power of eminent domain.

The General Assembly enacted legislation in 1969 which changes the procedure for determination of water rights and changes in and transfers of water rights, and provides for plans for augmentation. It is not applicable to designated ground water basins nor to wells solely for stock watering, domestic or other purposes, not exceeding 50 gallons per minute of flow. Determination of water rights should be more efficient, less expensive, faster and more accurate under the new legislation.

Any person who desires a determination of a water right or conditional water right, and the amount and priority thereof, including a determination that a conditional water right has become a water right by reason of completion of the appropriation, or changes in water rights, or plans for augmentation or biennial findings of reasonable diligence shall make verified application to the water clerk. Those opposing the application may file a statement of opposition. After publication of the application and investigation, the referee may rule on it without conduting a formal hearing, or may refer it to the water judge for his decision. Protests of the referee's ruling, as well as referrals above mentioned, will be heard by the water judge in accordance with trial practice and procedure. The water judge shall either confirm, modify, reverse, or reverse and remand the ruling of the referee, and his judgement and decree shall contain all pertinent information necessary.

Water may be stored either in channel or off-channel reservoirs for future beneficial use. Decrees covering such storage rights may be awarded as for other means of diversion. The storage of water must be followed by application to beneficial use, which term by statute also includes impoundment for recreational purposes, fishery and wildlife. The quantity of water to be stored must be defined, and, in the case of off-channel reservoirs, the capacity of the inlet works must be described in the same

manner as that used for direct diversion canals. A reservoir decree permits taking and storing water in the order of its priority. Direct flow uses having priority dates junior to a reservoir may not take water when the reservoir right is unsatisfied. Under each reservoir decree ordinarily there may be but one filling of the reservoir per year unless there is free water in the stream not demanded by other appropriators. A reservoir can secure decrees permitting more than one filling under some conditions, but such decrees must take their proper places in the priority schedule. If a change of place of storage can be accomplished without injury to vested rights, it may be granted in an appropriate transfer proceeding. By statute, a reservoir owner is made the virtual insurer against loss or damage occasioned by failure of the reservoir. The problem of the passage of direct flow water through a reservoir has caused some controversy. The state engineer may order releases equal to net evaporation from an on-stream reservoir for other appropriators. Direct flow water may be passed through a reservoir system if it is not actually stored therein.

Responsibility for water administration and control in Colorado is divided between the state engineer, who is the executive officer of the Division of Water Resources of the State Department of Natural Resources, and the judiciary, specifically one district court judge, designated a water judge, for each of the seven water divisions of the state. The state engineer has exclusive jurisdiction to administer, distribute, and regulate the waters of the state. The water judges, on the other hand, have exclusive jurisdiction over *water matters* in the state district courts within their respective divisions. Water matters are those matters which are specified by statute to be heard by water judges. They include determinations of amounts and priorities on applications for new water rights and conditional water rights, and determinations of rights with respect to proposed changes of water rights, plans for augmentation, and biennial findings of diligence in the perfection of conditional rights.

Among the more important duties of the state and division engineers is the tabulation of decreed water rights. Before 1969, no system had been devised to keep statewide or division records of all the decreed priorities drawing water from the same common source of supply.

In 1969, the Colorado General Assembly authorized preparation of these tabulations. The division engineers were directed, not later than October 10, 1973 to prepare tabulations of all decreed water rights in their respective divisions in order of seniority, setting forth the priority and amount of each right as established by decrees. These initial tabulations, prepared for administrative purposes, were to serve as a basis for preparation of another set of tabulations to be completed by July 1, 1974 and for successive revisions of the tabulations in even-numbered years after 1974. The 1974 and succeeding tabulations are to be filed in court for adjudication by the water judge for each division. After adjudication, during which opportunities are to be

afforded for protests, the water judge for each division is directed to enter a judgment and decree either incorporating the tabulation as filed, or incorporating the tabulation with such modifications as the water judge may determine proper. Appellate review of the judgment and decree may be had as in other civil actions.

Underground waters for many years have been used in Colorado without being properly within the priority system. Much effort was made by the General Assembly with the help of engineers and attorneys during the 1969 session to remedy the situation. General policies relating to integration of tributary ground water into the priority system are contained in the introduction.

In determining and administering the use of water, judicial and administrative officers shall be governed by the following: (a) If an appropriator uses a well, he may charge that diversion to his own appropriation or, if he also has a surface right taking from the same stream system, he may, by using the proper procedure, have the well as an alternate point of diversion for his surface decree; (b) the widest possible discretion to permit the use of wells shall prevail. Lowering of the water table will be allowed if it later can be recharged so as to prevent injury to senior appropriators; and (c) as in other parts of the new legislation provision is made for the interim period until procedures and paper work can be finalized.

There are some areas of the state where considerable quantities of ground water can be found which do not contribute to adjudicated surface rights. Specific examples are the Closed Basin of the Rio Grande and the Republican River drainage in the High Plains area. Wells in these areas, if in sufficient number, will compete with each other as surely as do ditches from surface streams.

Designated ground water is subject to appropriation and is defined in the law as follows:

1. *That ground water which in its natural course would not be available to and required for the fullfillment of decreed surface rights.*

2. *Ground water in areas not adjacent to a continuously flowing natural stream, wherein ground water withdrawals have constituted the principal water usage for at least 15 years preceding January 1, 1965.*

The law provides for a ground water commission which has the authority to establish designated ground water basins in accordance with the definition of designated ground water as above set forth. The procedure for establishing such ground water basins is set forth in the legislation which includes public hearings and publication.

After having designated a ground water basin, the commission, through the state engineer, will issue permits for the use of ground water and establish a priority date and number for each well in accordance with the doctrine of prior appropriation. However, if the commission finds that the issuance of any future permit would unreasonably impair any existing use or would result in the unreasonable lowering of the water table, then a permit may be denied. The procedure for hearing and publication on all future permits is provided for in the legislation. The priority date of future wells is the date of filing the request for permit with the state engineer.

The ground water commission is given rather broad powers to conserve the ground water resources of the designated basins and to protect vested rights of other appropriators. The state engineer is the enforcing officer for the commission.

Within areas determined as designated ground water basins by the ground water commission, local ground water management districts may be formed. Formation is through a vote of the local people. If a district is formed, then the district itself has broad general powers of management over the ground water resources of the designated area. Decisions of local districts may be appealed to the commission. The powers and functions of the ground water district are quite comprehensive and are fully set forth in the legislation.

State of New Mexico

ACQUISITION, ADJUDICATION & ADMINISTRATION OF WATER RIGHTS

New Mexico's constitution recognizes and confirms all existing rights to the use of any waters for any useful and beneficial purpose. Beneficial use is defined as *the basis, the measure, and the limit of the right to the use of water.* The constitution further provides that *the unappropriated water of every natural stream, perennial or torrential, within the state of New Mexico is hereby declared to belong to the public and to be subject to appropriation for beneficial use, in accordance with the laws of the state. Priority of appropriation shall give the better right.* The underlying principle is known as the appropriation doctrine of water rights.

The New Mexico surface water code, enacted in essentially its present form in 1907, gives the state engineer general supervision of the measurement and apportionment of the surface waters of the state. After March 19, 1907 any right to the use of public waters must be initiated by application to the state engineer as provided by statute. The law makes it illegal to initiate the construction of works for the diversion or storage of water, or to change the point of diversion or place or purpose of use of a water right, without the permit of the state engineer. The law requires the publication of notice of application to the state

engineer, gives opportunity to protest the granting of an application, and provides for a hearing before the state engineer. Decisions of the state engineer are subject to appeal to the district court.

The statutes do not require an application to the state engineer for stock dams whose maximum storage capacity does not exceed 10 acre-feet. The owners are, however responsible for any detriment or damage to prior water rights which may result from the construction of, and storage of, water in such stock ponds.

The New Mexico ground water code, enacted in substantially its present form in 1931, closely parallels the surface water code in its essentials. Under its terms, when the state engineer finds that the waters of an underground supply have reasonably ascertainable boundaries, and when he so proclaims, he assumes jurisdiction over the appropriation of such waters. He proclaims, or declares, underground water basins by the issuance of appropriate orders and by publication of a description of the basin boundaries. The state engineer declares underground water basins when it becomes apparent that regulation is necessary to protect prior appropriations, to insure beneficial use of water, and to insure the orderly development of the water resources.

The statutes permit the filing of declarations of right based upon beneficial use existing in a new basin or an extension of a declared basin of the date of his order or declaration. Any new right to the use of waters in a declared underground water basin must originate by application to the state engineer.

The public is notified of proposed appropriations by publication of each application in a newspaper of general circulation in the county in which the proposed well will be located and any owner of a water right in the basin who feels that the use of water under such proposal will impair his right may file a protest thereto.

If no objection or protest is filed, the state engineer shall approve the application in whole or in part, if he finds that there are unappropriated waters or that the proposed application will not impair existing rights. If protest has been filed and applicant and protestant are unable to reach an agreement, the state engineer shall hold a hearing on the application after which he will either approve the application or reject it. His decision is subject to appeal to the district court.

The right to the use of underground water for irrigation purposes is appurtenant to the land upon which it is used and shall so continue as long as it is beneficially used or until it is lawfully severed from the land. Water which is appurtenant to certain lands may be transferred to other lands or other uses only as provided by law and with the consent of the owner of the land.

Ground water outside the boundaries of declared underground water basins also belongs to the public and is subject to appropriation, but it may be developed and put to beneficial use without a permit from the state engineer.

The New Mexico legislature incorporated into the water code provisions authorizing the state engineer to accomplish hydrographic surveys and secure general adjudications of rights to surface and ground water within the state. Pursuant to this statute, the state engineer has undertaken a large-scale program of water rights adjudication.

New Mexico water law provides for coordinated administration of interrelated surface and ground water supplies.

In New Mexico, the state's water program reflects the recognition of the need for the development of water for agricultural, municipal and industrial uses, with attention to the growing demands of water related recreation. In many areas of the state, growing municipal and industrial needs can be met only by acquiring water rights presently being exercised for irrigation. The statutes, recognizing an intrinsic property of a water right held under the doctrine of prior appropriation, permit the change in point of diversion and the change of place and purpose of use of water rights, if such changes can be accomplished without impairment of other existing rights.

State of Utah

ACQUISITION, ADJUDICATION & ADMINISTRATION OF WATER RIGHTS

The basis of Utah's present day procedure for appropriating water was the Act of 1903 which was subsequently revised and reenacted into what is today a broad and comprehensive water code.

Th Utah Supreme Court has upheld the constitutionality of Utah's present water right law and declared that the state has the right to control the appropriation and distribution of the public waters within its boundaries.

The current Utah statutes provide that all waters in this state, whether above or under the ground, are public property and that rights to use the unappropriated waters can only be acquired by filing an application to appropriate. This statutory procedure is now the exclusive method of appropriating water in this state. Applications to appropriate are filed in the office of the state engineer and unappropriated water may be acquired for any recognized beneficial use.

Upon receipt of an application, notice is published in the county where the point of diversion is located and protests against the application may be submitted within 30 days following the last publication date. If

a protest is filed the state engineer conducts an informal hearing with the applicant and the protestant and receives whatever relevant evidence the parties desire to submit.

Before approving an application, the state engineer must find that there is unappropriated water in the source that can be diverted without interfering with existing rights. He must also conclude that the application is engineeringly and economically feasible and that the application is not contrary to the general public welfare and is not filed for purposes of speculation and monopoly. As will be discussed in more detail later, the decision of the state engineer is subject to appeal to the district court.

Once an application is approved, the applicant is given a specific time within which to place the water to beneficial use and submit a written proof of appropriation. An applicant may be granted additional time for completing construction of the works and applying the water to beneficial use upon a showing of diligence or a reasonable cause for delay. This statute allows the state engineer to grant up to 50 years to accomplish this work. The Utah Supreme Court has ruled that in order for an applicant to be entitled to a further extension of time, he must make a constant effort to accomplish his undertaking as is usual with men engaged in a like enterprise who desire a speedy accomplishment of their designs.

The question of due diligence has been one of great concern in the state of Utah in recent years because an applicant with an approved application who fails to place the water to beneficial use is tying up the water supply and precluding the full and complete utilization of this limited resource by others. Therefore, in recent years, the state engineer's office has required applicants with relatively small projects to complete construction of their works and place the water to beneficial use ithin a period of a few years. If this is not done, further extensions of time are denied and the application is lapsed. This program has resulted in clearing the state engineer's records of many applications under which no development had taken place. However, as demands for water increase in the future, it will undoubtedly become necessary to adopt an even more rigid policy on extension requests. Once the water is placed to beneficial use, the applicant submits proof of his appropriation and is issued a certificate of appropriation, which is recorded in the County Recorder's Office. Thereafter, the only requirement is that there be a continued beneficial use of water in the manner provided for in the certificate.

Utah has an integrated administrative-judicial proceedings for the determination of the rights to the use of any stream or water source in the state. Such action can be initiated by the state engineer upon petition of waterusers, or the court can, in litigation involving water rights, order a general adjudication. Once a general adjudication proceedings have been initiated, the state engineer undertakes a hydrographic survey of the source involved and receives waterusers claims

from the various users. These claims stand in the place of pleadings, and issues may be framed thereon.

From these sources and other information gathered by him during his investigation, the state engineer prepares a proposed determination of water rights. This document is mailed to the individual users and they have an opportunity to submit written protests to the district court if they disagree with the engineer's proposals. Any protests which are submitted are tried before the district court with all the interested parties present. The district court's ruling may be appealed to the Utah Supreme Court. If no protests are filed, the district court enters judgment in accordance with the proposed determination of water rights as submitted by the state engineer. The Utah Supreme Court, in some relatively early cases, upheld the constitutionality of various aspects of this case.

The state engineer has general administrative supervision of the distribution of the waters of the state. He may, after consultation with the waterusers on a given source, appoint a commissioner who makes the actual distribution of the water to the various users. The salary and expenses of the commissioner are paid by the individual waterusers on a pro rata basis. To assist the commissioner in the distribution of water, the state engineer may require users to install proper measuring devices and control structures. With certain exceptions, the state engineer has supervision over the construction, maintenance, repair and operation of dams to insure the safety of persons and to protect property.

The engineer may determine whether an existing underground water supply is adequate for existing claims. If, after proper notice and hearing, he determines that there is an inadequate supply for all claims, he may distribute the water in accordance with the priority of the claims.

Reserved Water Rights

The western states are often referred to as the *public lands states*. This is because much of the ownership has been carved out of the public domain, and because vast areas are still in federal public ownership. Part of the public domain lands were reserved under various authorities for specific purposes such as Indian reservations, national forests, national parks, military reservations, and others.

When these lands were reserved there was also reserved a right to use water reasonably necessary for the purposes of the reservation. This reserved right has never been fully defined, but its existence has been reaffirmed in several state court decisions, and by the United States Supreme Court. Obviously, the purposes for which water is requied would be different on a military reservation than on a national forest. One thing in common, however, is that the priority date is established by

the date of creation of the reservation. Therefore, an appropriative right acquired under state law before creation of a reservation has priority over the reserved right.

Unlike appropriative water rights, reserved rights neither require nor prevent diversion or impoundment for beneficial use. For example, in-stream flows may be reserved for fisheries, recreation, vegetation, aesthetics, or other purposes of the particular reservation. Even though such claims are established, much of the same water is available for appropriation at points downstream.

In general stream adjudications, reserved water rights are subject to state judicial proceedings along with appropriative rights.

Interstate Compacts

While the constitutions and water laws of Arizona, Colorado, New Mexico and Utah stipulate that the water of natural streams is dedicated to the use of the people of the respective states, these provisions are subject to decision of the U.S. Supreme Court which provides for an equitable apportionment of the benefits of an interstate stream. Consistent with this decision, there must be a division of the waters of all interstate streams, this division may be accomplished either by decree of the U.S. Supreme Court or by interstate compacts consented to by the Congress.

The four states listed above have by compacts secured a definition of their rights to the water from the Colorado River and its tributary, the San Juan River.

COLORADO RIVER COMPACT

Basically, the Colorado River Compact sought to accomplish a division of part of the waters from the Colorado River system. The principal features of this compact are as follows:

1. The Colorado River Basin is divided into two subbasins with Lees Ferry being made the division point. The Upper Basin consists of that part of the states of Arizona, Colorado, New Mexico, Utah and Wyoming from which the natural drainage is above Lees Ferry. The Lower Basin consists of that part of the states of Arizona, California, New Mexico, Nevada and Utah from which the natural drainage is below Lees Ferry. Also included as a part of the basins is any part of these states which uses Colorado River system waters. The Upper and the Lower Basins are each granted the exclusive beneficial consumptive use of 7,500,000 acre-feet per annum from the Colorado River system. The Lower

Basin is granted the right to increase its beneficial consumptive use by 1,000,000 acre-feet per annum.

2. There is a provision for the sharing of any burden which might arise because of a water treaty with Mexico. It was determined that such burden should be met first from the "surplus" which might be in the river over the allocations made to the Upper and Lower Basins by the articles above mentioned. If such surplus should prove insufficient, provision is made for the sharing of such deficiency.

3. There is a provision made for the insurance of a certain quantity of water passing from the Upper Basin to the Lower Basin at Lees Ferry. This was accomplished by an agreement on the part of the Upper division (the states of Colorado, New Mexico, Utah, and Wyoming) not to cause the flow of the Colorado River to be depleted below an aggregate of 75,000,000 acre-feet for any consecutive 10-year period reckoned in continuing progressive series.

4. There is a provision made whereby the Upper Division states are not to withhold water and the Lower Division states are not to require delivery of water which could not be applied to domestic and agricultural uses.

5. There are provisions for further equitable apportionment after October 1, 1963.

6. The Compact attempts to insure that agriculture and domestic uses will have a priority.

7. There are provisions made for the means of settlement of controversies.

8. United States' obligations with respect to Indian tribes within the Basin are to remain unaffected and present perfected rights are to be inimpaired by the Compact.

9. There are the necessary provisions for the ratification of the Compact.

UPPER COLORADO RIVER BASIN COMPACT

This Compact between the states of Arizona, Colorado, New Mexico, Utah and Wyoming and the U.S. government apportions waters of the Upper Colorado River Basin which had been alloted to the Upper Basin states by the Colorado River Compact.

Of the Upper Basin allocation, Arizona was allotted 50,000 acre-feet annually. The remaining states were allocated the following percentages of the remainder: Colorado - 51.75%; New Mexico - 11.25%; Utah - 23.00%; and Wyoming - 14.00%.

The Compact makes provision for the division and measurement of uses of certain tributaries of the Colorado River in the Upper Basin which serves as a source of water for two signatory states. Tributaries dealt with include:

1. Little Snake River - Colorado and Wyoming.
2. Henry's Fork - Utah and Wyoming.
3. Yampa River - Colorado and Utah.
4. San Juan River - Colorado and New Mexico.
5. La Plata River - Colorado and New Mexico.

LA PLATA RIVER COMPACT - 1922

At the same time that the Colorado River Compact was negotiated, Colorado and New Mexico negotiated and executed the La Plata River Compact.

This compact provides for the division of the water of the La Plata River between the two states as follows:

1. Between December 1 and February 15 of the succeeding year, each state shall have unrestricted use of the water of the river flowing within its boundaries.

2. Between February 15 and December 1 of each year, the flow is apportioned as follows:

   a. Each state is to be unrestricted in the use of water within its boundaries on each day when the mean flow at the interstate station is 100 c.f.s. or more.

   b. On all other days, Colorado is to deliver at the interstate station one-half previous day's flow at Hesperus Station, but not more than 100 c.f.s.

3. In times of low water, the state engineers of the two states can agree to rotation schedule of use of all water in lieu of the provisions of (2) above.

4. Colorado is not required to deliver any water to New Mexico not then necessary for beneficial use in New Mexico.

ANIMAS-LA PLATA PROJECT COMPACT

The Animas-La Plata Project Compact has been entered into in order to clarify the relationship between Colorado and New Mexico waterusers on the Animas-La Plata Project, authorized by Public Law 90-537.

The Compact makes the priority of the New Mexico waterusers of the Animas-La Plata Project water equal to the decreed rights of the Colorado waterusers who take water from the same project.

RECREATION RESOURCES

Natural Features

The San Juan Basin's remarkable recreation attractions, such as fishing, boating, camping, waterskiing, rock hounding, and sightseeing, need no justification other than the pleasure they bring. Although the area has many developed attractions and facilities for outdoor recreation, there are many natural, historical, and scenic resources still undeveloped which have great potential for attracting additional visitors for longer periods.

The area is varied in countryside. From semiarid land in the south, travelers pass suddenly into rich farmland, onto forested mesas, and finally, into high mountain wilderness national forests. There, recreationists can see nature in an unspoiled array, traveling through dense forests and along sparkling streams -- a year around vacationland offering excellent fishing, big game hunting, and skiing.

Existing Outdoor Recreation Areas 3/

The character of the natural features, rather than the location of the basin, have dominated the kind of cultural development and thereby, affect the amount and kinds of recreational use in the area. Both archeological and historical values have a significant effect on present day recreation activities.

HISTORICAL VALUES

Durango-Silverton Narrow Gauge Line, Colorado

The Silverton, a narrow gauge passenger train, runs through the rugged mountainous terrain of the San Juan country between Durango and Silverton. The original line served as an outlet for the booming mining towns and

3/ *This section draws heavily from the Upper Colorado Region Comprehensive Framework Study, Appendix XII, Recreation, Regional Summary.*

has been in continuous use since 1882. This scenic railroad has been designated a historical monument.

Narrow Gauge Train - Durango to Silverton
SCS PHOTO

Hubbell Trading Post, Ganado, Arizona

The Hubbell Trading Post is the oldest continuously operated trading post on the Navajo Reservation and has little changed since its establishment nearly a century ago.

Silverton, Colorado

In the center of the San Juan mining district, Silverton was once a boom mining town. Buildings such as the Grand Imperial Hotel, an 1880's showplace of the silver kings, and the gold-domed courthouse lend evidence of the former prosperity of Silverton.

ARCHEOLOGICAL VALUES

Chaco Canyon National Monument in northwest New Mexico contains the earliest and largest Pueblo ruins. Dating from about 1000 A.D., these spectacular ruined villages display the richest ceremonial development in the Anasazi area. The Mesa Verde Anasazi, spectacularly preserved in Mesa Verde National Park were closely related to Chaco, and adapted many similar patterns to a forestal plateau environment. Cliff Palace, the largest cliff dwelling in the area, is one of many sites preserving the distinctive architectural features of the region. In northeast Arizona, the Anasazi population was apparently less dense than in the Chaco and Mesa Verde areas. Keyenta Anasazi villages, like Vetatakin and Keet Seel in Navajo National Monument, show considerably less stylized architectural techniques and settlement patterns.

MAJOR RECREATION ATTRACTIONS

The sparsity of resident population and developments are a reflection of the character of the area and also influences the recreation use. The majority of nonresident recreationists do not venture from hard-surface roads and use services that are found only in the widely spaced towns or in the better developed campgrounds. Consequently, vast areas receive use from only the most hardy recreationists.

The major recreation use areas in the basin are: San Juan National Forest, Manti-La Sal National Forest, Carson National Forest, Mesa Verde National Park, Aztec Ruins National Monument, Hovenweep National Monument, Chaco Canyon National Monument, Canyon de Chelly National Monument, Monument Valley, Navajo National Monument, Natural Bridges National Monument, Glen Canyon National Recreation Area, Navajo Reservoir, Vallecito Reservoir, Williams Creek Reservoir and the Four Corners National Monument.

Navajo Reservoir Recreation Area Marina
New Mexico SCS PHOTO

Inventory

LAND - WATER

Basic inventory data was borrowed from Appendix XII, Recreation, Upper Colorado Region Comprehensive Framework Study and adjusted to the San Juan Type IV River Basin boundaries. The inventory of existing recreation resources was made by the Bureau of Outdoor Recreation using the Classification Categories of Land. 4/ Each recreation area was assigned a single class in accord with the intended use for which the area was established. The inventory of lands for recreation and water surface supporting each class of recreation is presented in Table III-22.

4/ *Land classification under this system includes: Class I - High Density Recreation Areas; Class II - General Outdoor Recreation Areas; Class III - Natural Environment Areas; Class IV - Outstanding Natural Areas; Class V - Primitive (Wilderness) Areas; and Class VI - Historic and Cultural Sites.*

Table III-22.--Inventory of developed and undeveloped land for recreation in the San Juan River Basin, 1965 1/

State	Total Inventory Developed Land 2/	Total Inventory Undeveloped Land 3/	Total Inventory Surface Water 4/
	Acres		
Arizona	4,105	1,652,303	1,000
Colorado	5,844	2,406,442	10,511
New Mexico	4,080	2,426,340	17,019
Utah	6,648	4,830,607	5,740
TOTAL	20,677	11,315,692	34,270

1/ Data were taken from the Comprehensive Framework Study - Upper Colorado San Juan, Addendum A-1 of the Recreation Area Inventory and reflects the hydrologic boundaries of the San Juan Type IV River Basin Study.

2/ Developed lands are those with relatively intensive developments of any type of recreation facilities, recreation roads, or other visitor improvements.

3/ Undeveloped lands are those that support developed areas that provide a quality environment, buffer area or scenic backdrop that provide for extensive recreation activities, such as hunting and nature walks; or that are characterized by important wilderness, geologic or other natured values.

4/ The inventory included both marsh and water surface acreage.

IV. ECONOMIC DEVELOPMENT

HISTORICAL DEVELOPMENT

First Settlement

COLORADO

The first settlers into the region were attracted by the gold and silver discovery in the 1870's. Soon after, cattlemen and ranchers settled the Animas Valley in present La Plata County. Cattle from Texas and other areas of Colorado were brought into the area. Durango grew after the establishment of the Denver and Rio Grande Railroad to ship cattle eastward. The first settlers into the present Montezuma County were sheep and cattle ranchers. The town of Mancos was established in 1881. The town of Dolores was started when the Rio Grande and Southern Railroad located a depot there in 1892. Cortez was founded in 1886 as a result of the construction of a large irrigation project by which water was brought from the Dolores River to the Montezuma Valley. The Pagosa Springs area had some inhabitants by 1859, but the townsite was not plotted until 1880. Timber and cattle were important industries. 1/

NEW MEXICO

Farmington was first settled in 1876 as cattle ranching began. Land cultivation followed shortly afterwards when the first irrigation ditch was built for irrigating fruit and row crops. Aztec was the site of a profitable trapping industry until 1826 when beaver became exterminated. A townsite was laid out in 1890 but there was little growth until 1905. Since then, it has been a prosperous fruit growing center. Bloomfield was settled in 1881 and since then, became a prosperous agricultural town growing large crops of grain, beans, and other produce. 2/

UTAH

Most early settlement was centered at Bluff by Mormon pioneers in the 1880's. The first paying industry was cattle with sheep a close second. It is estimated that in the 1880's the two largest cattle companies alone grazed over 50,000 head near the Blue Mountains. The range at this time was tax free and the cattle barons of New Mexico,

1/ *Hafen, Leroy R. Colorado and It's People, Vol. 1, 1948.*

2/ *Work Project Administration, New Mexico. A guide to a colorful state, 1940.*

Colorado, and Texas took advantage of this. As a result, the range soon became overstocked. 3/

ARIZONA

Nomadic tribes of Navajos and Apache were the only inhabitants until white settlers appeared. Little, if any, settlement occurred and the area was eventually established as a reservation. Use of the land was devoted to sparse grazing by cattle and sheep.

Agricultural Settlement

In the early settlement of the San Juan Valley, the homeseeker with a few head of livestock, preempted land along rivers. As herds grew in number, cattle and later sheep, rapidly became the leading industry.

Overgrazing soon created severe land resource use problems. Adjacent to the rivers, early settlers also exploited other agricultural capabilities. Water, diverted from rivers, was used to irrigate cultivated fields of vegetables, fruit, and alfalfa. Since remoteness from a railroad and market made it impractical to export the vegetables and fruit commercially, the commodities were consumed locally. Consequently, production of cattle became the primary source of income. With the turn of the century and the increase of available irrigation water, agricultural crops were produced in support of cattle and dairy enterprises.

Mining Exploits

Mining activity played an important role in the settlement of the valley. Gold and silver discovery enticed early settlers to Silverton and La Plata Canyon. The early mining industry gradually began to wane in the late 1920's when resources were depleted and the market for the minerals declined. Radium mining began after the turn of the century when the federal government created the National Radium Institute for Cancer Research. Radium was also in demand for its luminous properties. During World War II, uranium production was greatly accelerated and contributed to an increase in population as well as to the Basin's overall economy.

3/ *San Juan Daughters of Utah Pioneers, Saga of San Juan, 1937.*

CURRENT AND PROJECTED DEVELOPMENT

The San Juan River Basin has had a growing population since the early part of this century. Historically, economic growth was dependent on the agricultural and mining industries. However, since 1950 the basin economy has become more dependent on the growing tourist industry and development of the mining-energy complex.

A major shift has occurred in the relative importance of the basin's employment sectors. Between 1950 and 1965 employment in agriculture declined from 36 percent of total employment to 8 percent of total employment. Employment in mining, transportation, electric energy and other utilities increased from 36 percent of total employment to 53 percent of total employment (Table IV-1).

A continued decline in agricultural employment is expected in the future. Consolidation of small farms into larger units and increased labor productivity is expected to more than offset increased levels of agricultural production.

Employment in mining, transportation, electric energy and other utilities is expected to increase in the future. Coal, natural gas, natural gas liquids, petroleum, uranium, stone, sand and gravel, zinc, lead, copper, silver, and gold are mined in the basin. Coal-fired steam electric generation facilities and a coal gasification plant are planned in New Mexico.

Table IV-1.--Historical and projected population and employment, San Juan economic region, 1/ regional interpretation of OBE-ERS projections

	Year				
	1950	1965	1980	2000	2020
Population, number	61,634	99,625	150,337	202,915	273,464
	Employment Number				
Agriculture & Forestry	6,945	2,455	1,695	1,510	1,455
Mining	1,118	4,085	8,460	8,690	8,905
Transportation, Electric Energy & Other Utilities	1,509	2,795	4,582	6,028	6,782
Construction	1,460	2,536	3,954	5,292	6,603
Manufacturing	1,209	2,056	3,620	4,409	5,057
Trade & Services	6,990	15,793	28,052	46,106	71,286
Total Employment	19,231	29,720	50,363	72,035	100,088

Source: Upper Colorado Region Comprehensive Framework Study, Appendix IV, Economic Base and Projections, June 1971.

1/ The San Juan economic region includes San Juan County in New Mexico, Archuleta, La Plata, Montezuma, and San Juan counties in Colorado; and San Juan, Wayne, Garfield, and Kane counties in Utah.

Employment in trade and service industries is expected to grow faster than employment in other sectors of the basin economy. The increase reflects the national trend to a service-oriented economy as well as increased recreational activity. Tourists are drawn to the basin by its many recreational attractions (see discussion of recreation resources in Chapter III). The majority of recreationists travel to the basin from metropolitan areas in surrounding states. Recreationists spent more than $18 million in the San Juan recreation region in 1965. Historical and projected levels of recreation activity and recreationist expenditures are shown in Table IV-2.

Table IV-2.--Historical and projected recreation activity and recreationist expenditures, San Juan recreation region 1/

Year	Recreation Days (1000) Resident	Nonresident	Total	Recreationist ($ millions) Expenditures
1965	930	17,248	18,178	18.5
1980	1,522	26,139	27,661	24.2
2000	2,568	42,693	45,261	34.1
2020	3,783	69,164	72,947	47.1

Source: Upper Colorado Region Comprehensive Framework Study, Appendix XII, Recreation, June 1971.

1/ The San Juan recreation region is the hydrologic counterpart to the San Juan economic region. San Juan and portions of McKinley, Rio Arriba, and Sandoval counties in New Mexico; La Plata, Archuleta, San Juan and portions of Montezuma, Dolores, Hinsdale, and Mineral counties in Colorado; portions of Apache, Navajo, and Coconino counties in Arizona; and portions of Kane, Garfield, Wayne, Sevier, Emery, and San Juan counties in Utah are included.

Agriculture

Total sales of agricultural products in the San Juan economic region reached $26 million in 1969. Livestock and livestock product sales were $19.5 million while crop sales were $6.5 million.

The cattle and sheep segments of the livestock industry dominate the region's agriculture. Hay, pasture, silage, and feed grains are grown to support the livestock industry. Nearly 95 percent of irrigated

cropland harvested and 17 percent of dry cropland harvested was used to produce livestock related crops in 1965. The remainder of livestock forage needs are provided by grazing on rangeland.

Irrigated Hayland, Florida Mesa, Colorado
SCS PHOTO

Many of the farms in the region are too small to provide an adequate level of living without income from other sources. In 1969 only 27 percent of the 2,465 farms in the region had sales of $10,000 or more. Consolidation of farms into larger units is expected to continue.

Table IV-3.--Farm Characteristics, San Juan economic region, 1969

Value of farm products sold (dollars)	26,000,000
Crops	6,500,000
Livestock	19,500,000
Number of Farms	2,465
Number of Farms with sales of $10,000 or more	656
Average value of farm products sold per farm (dollars)	10,500

Source: 1969 Census of Agriculture

Table IV-4.--Cropland harvested, San Juan economic region, 1965

Crop	Irrigated Acres	Nonirrigated Acres
Hay and pasture	214,900	39,400
Silage	11,700	---
Feed grains	13,600	2,600
Wheat	7,400	89,800
Dry Beans	500	118,000
Other	5,600	400
Total	253,700	250,200

Source: Upper Colorado Region Comprehensive Framework Study, Appendix IV, Economic Base and Projections, June 1971.

Water Depletion

Agriculture is the largest water user in the San Juan economic region. Agriculture accounted for nearly 93 percent of total water depletion in 1965. Electric power generation is the second largest water user. Power generation accounted for less than 4 percent of total water depletion in 1965.

Historical and projected water supply and depletion associated with historical and projected levels of economic activity in the San Juan economic region are shown in Table IV-5. Water depletions by agriculture are projected to more than double by 2020. Water depletions for transportation, electric power generation, and other utilities are projected to increase more than tenfold. Total regional depletions are projected to nearly triple by 2020.

Table IV-5.--Historical and projected water supply and depletion, San Juan economic region, regional interpretation of OBERS projections

	Year			
	1965	1980	2000	2020
	Supplies, acre-feet			
Total natural supply	2,606,000	2,606,00	2,606,000	2,606,000
Import from Dolores River Basin	100,700	227,600	227,600	227,600
Export to Rio Grande River Basin	2,500	120,500	120,500	120,500
Total regional supply	2,704,200	2,713,100	2,713,100	2,713,100
	Depletions, acre-feet			
Agriculture	388,291	603,751	768,672	931,633
Mining	5,270	7,800	7,776	8,069
Transportation, electric energy & other utilities	15,440	126,488	199,169	176,427
Construction	1,093	2,022	4,188	8,343
Manufacturing	650	1,660	3,192	5,939
Trade & Services	977	1,769	3,233	6,272
Households	3,388	8,419	12,273	17,459
Fish and Wildlife	2,400	30,500	30,500	30,500
Recreation	300	600	1,000	1,700
Total Regional Depletion	417,809	783,009	1,030,003	1,186,342
Residual Flow to Lake Powell	2,286,391	1,930,091	1,683,097	1,526,758

Source: Upper Colorado Region Comprehensive Framework Study, Appendix IV, Economic Base and Projections and Appendix V, Water Resources, 1971.

Projection Alternatives

Projection of future levels of population, economic activity, and water depletion is far from an exact science. The regionally interpreted OBE-ERS projections used as the framework for this study represent one of several projection alternatives available. A comparison of population projection alternatives is shown in Table IV-6. Each alternative is based on different assumptions about birth rates, levels of economic activity, and the region's industrial mix.

The 1968 OBE-ERS projections and the 1972 OBERS projections were based on Series C population estimates of the Bureau of the Census. However, the 1972 projections were based on data obtained in the 1970 Census of Population which was not available for the 1968 projections. They are based on trend relationships and do not explicitly consider the impact of proposed mining and energy development.

The regional interpretation of OBE-ERS projections were based on the 1968 OBE-ERS projections. However, the projections were modified to account for planned developments in mining and electric power generation. They were also modified to account for inconsistencies between projected livestock and feed production contained in the 1968 OBE-ERS projections. Feed crop production was increased from the OBE-ERS level to maintain consistency with the projected level of livestock production.

If the entire Upper Colorado basin is considered, a total water development of 6.5 million acre-feet was developed by the states. This represents the maximum level of development under terms of the Colorado River Compact (without imported water). The regional interpretation of OBERS projections was used as a base.

Including the possibility of imported water, the states developed a second alternative of 8.16 million acre-feet for the entire upper basin. This includes water evaporation from reservoirs related to deliveries at Lees Ferry and Mexican apportionment of Colorado River water in determining possible water depletions.

Table IV-6.--Alternative population projections for the San Juan economic region

Projection	Year 1980	2000	2020
Regional interpretation of OBE-ERS projections 1/	150,000	203,000	273,000
1968 OBE-ERS projections 2/	133,500	169,800	212,300
San Juan proportion of state's alternative-maximum development under compact terms 1/	163,000	212,000	283,000
San Juan proportion of state's alternative-maximum development with importation 1/	164,000	214,000	285,000
1972 OBERS projections 3/	115,400	142,700	180,100

1/ Source: Upper Colorado Region Comprehensive Framework Study, Appendix IV, Economic Base and Projections, U.S. Water Resources Council, June 1971.

2/ Source: Preliminary Report on Economic Projections for Selected Geographic Areas, 1929 to 2020, U.S. Water Resources Council, March 1968.

3/ Source: 1972 OBERS Projections, U.S. Water Resources Council, September 1972.

FORESTRY & RELATED ECONOMIC ACTIVITY

About 5-1/3 million acres in the basin are forest lands. This has a direct and substantial effect on local economies. Many residents of the rural communities depend upon the forests for their livelihood, either through the lumber and wood products industries, timber harvesting, forest related recreation and tourism, forest grazing, or forest management.

Historically, lumber has been the most important product of the timber industries. This has been changing in the past 15 years as softwood plywood and aspen paneling use more and more of the basins wood. The production of wood chips for pulp is also growing in economic importance.

In 1968 the total volume of wood produced in primary manufacturing was nearly 134 million board-feet. About 91 million board-feet or 68 percent of the total was lumber. Plywood and paneling production took about 40 million board-feet or 30 percent of the total output. Match splints, posts, poles, mine timbers, and other minor products account for the remaining 2 percent. Table IV-7 shows the output of timber products by product and species.

The total value of these major wood products was in excess of $16 million (Figure IV-1). The aggregate operating expenses of the 14 forest products industries in the basin in 1968 was:

Supplies	$1,215,700
Utilities	477,500
Services	210,300
Taxes (local property)	162,000
TOTAL	$2,065,500

Capital assets were reported as being over $51 million.

Although some of the timber products are sold in the basin states, most of the wood products are shipped to markets in California, Texas, Illinois, Indiana, Michigan, Wisconsin, and Ohio.

The U.S. Treasury receives the money from timber sales on national forest lands. Twenty-five percent of the receipts are returned to the counties where the timber was cut.

The output of timber products is given in Table IV-7.

Table IV-7.--Output of timber products by species in Arizona, Colorado, New Mexico and Utah (Board-feet, International 1/4-inch log rule) San Juan River Basin, 1968

	Species					
	Ponderosa Pine	Spruce Fir	Douglas Fir	Aspen	Total	Percent
	(000)					
Lumber	31,165	58,205	910	570	90,850	68.0
Plywood	7,560	30,240			37,800	28.0
Paneling				2,000	2,000	1.5
Match splints				3,000	3,000	2.0
Posts, poles, mine timbers & other products	35	50			85	.5
TOTAL	38,760	88,495	910	5,570	133,735	100.0

Source: U.S. Forest Service

Table IV-8.--Supply of growing stock and production of domestic roundwood in 1962 with projections of supply and demand to 1980, 2000, and 2020, San Juan River Basin

	Supply of Growing Stock 1/	Production and Demand of Domestic Roundwood 2/
	(million cubic feet)	
1962	65	10
1980	97	110
2000	106	153
2020	106	174

1/ Net volume of growing stock trees removed from inventory by harvesting, cultural operations, land clearing, or changes in land use.

2/ Logs, bolts, or other roundwood sections cut from trees for industrial or consumer uses.

Current & Future Timber Products Supply and Demand

In 1970 the Forest Service and other agencies cooperated with the Office of Business Economics (OBE) and the Economic Research Service (ERS) to produce a national assessment of water and related land resources. One result is a set of projections for timber supplies and demands for the years 1980, 2000 and 2020. The projections are for the Nation with allocations to major water regions and sub-basins. In 1962, the year of the assessment, the San Juan River Basin produced about 10 million cubic feet of industrial wood products. This was 100 percent sawtimber or about 50 to 60 million board feet.

Beginning in 1963 the production of wood products had a sharp upturn but production was still within the bounds of supply. The demand for wood products has continued to increase and according to national (OBERS) assessment projections, the demand for timber products may exceed the supply by 1980.

The demand will continue to outstrip supply by a widening margin for the remainder of the projection period if the assumptions concerning population, birth rate, market prices, income, current levels of management, and other conditions remain viable (Table IV-8).

The timber economy of the basin is largely dependent on sawmilling. The commercial forest land (1,451,300 acres) provide the resource base for the basin's plywood, match, and paneling plants. A breakdown of the 14 wood conversion plants in the basin in 1968 are:

Sawmills	11
Plywood plants	1
Paneling plants	1
Match plants	1

Part of the timber harvested for the mills and plants comes from outside the basin. Also, some of the timber in the basin is going to mills outside the basin. On the San Juan National Forest the established sawmill capacity now exceeds the allowable cut. Most mills do not operate at capacity.

Sawmill near Cortez, Colorado
SCS PHOTO

In 1968 primary timber processing industries in the basin provided 1,054 man-years of employment. These estimates include timber harvesting, but do not include employment in forest management and protection, nor do they include secondary manufacturing of forest products. These 1,054 employees in forest industries earned about $7,121,200 in wages and salaries, or an average annual salary of $6,756.

The projected timber products output will provide approximately three times the estimated 1968 employee man-years of work by the year 2020. These estimates are based upon the anticipated timber cut and upon improvements in the output per man-day.

Table IV-9 shows the estimated employment in each of the major industry components in 1968 and employment projections to 2020.

Table IV-9.--Estimated employment in timber based industries in 1968 and projections for 1980-2020 (number of employees), San Juan River Basin, Arizona, Colorado, New Mexico and Utah

Year	Total	Lumber and Wood Products			Pulp Paper and Allied Products	Timber Harvesting and Hauling
		Sawmills and Paneling Mills	Veneer and Plywood Plants	Match Plant		
1968	1,054	499	202	36	0	317
1980	2,010	1,253	260	40	0	457
2000	2,950	1,290	280	40	430	540
2020	2,940	1,535	300	40	485	580

Source: U.S. Forest Service

V. WATER AND RELATED LAND RESOURCE PROBLEMS

IRRIGATION & WATER SHORTAGE

Agriculture [1/]

Irrigation water shortage is probably the most limiting factor of agriculture production in the basin.

The surface water supply for irrigating cropland occurs as snowmelt runoff with the majority coming during April through June. Streamflows can diminish and be inadequate for the remainder of the growing season unless supplemented by storage water.

Table V-1 shows there are 73,500 acres of irrigated land with a water shortage problem, and 33,800 acres of idle land. These could be brought into full production with sufficient storage facilities to supplement the inadequate streamflows.

Inefficient irrigation water delivery systems from the diversion point to the farm contribute to the water shortage. It is estimated that 30 percent of the diverted streamflow is lost because of canal seepage and insufficient canal capacity at various locations prior to reaching the farm. Many miles of canal are usually involved from point of diversion to point of use. The diversion structure and canal originate at a much higher elevation than the irrigated area. Seeped areas have developed on the more pervious soils along the canal. The rehabilitation necessary to reduce seepage and improve the off-farm conveyance system efficiency includes: canal lining, canal resectioning (enlargement), and structures for protecting the canal from storm runoff.

On-farm inefficiencies reduce the overall irrigation efficiency by an additional 50 percent. This means that approximately 20 percent of the water diverted from the stream is used for crop consumption. Increasing on-farm efficiency can be accomplished by ditch system rehabilitation including pipelines, lining and water control structures. Irrigation water management improvements will be a continuing effort with new incentives and techniques needed to achieve results. Management includes timing and scheduling of irrigation water, proper application of water and improved technology on handling and controlling water.

1/ Much of this data is compiled from a study recently completed by the Soil Conservation Service on Water Conservation & Salvage Opportunities in the San Juan Basin, 1973.

Water shortages have discouraged some operators from making needed irrigation water management improvements, and imposed restrictions on cropping practices and crop rotations. Over-irrigation during spring runoff has resulted in some areas developing seep spots and salt accumulations. These excessive applications are an attempt to carry the crops through late season water shortage periods.

The delivery of irrigation water to the farm also delivers dissolved solids. The application of poor quality irrigation water without adequate leaching can cause cumulative salt buildup in the soil. On the other hand, over-irrigation causes excessive return flows which carry dissolved solids from the soil or underlying parent material to the stream causing pollution. These hazards suggest the need for proper irrigation and drainage practices.

Salt accumulation from excessive irrigation

SCS PHOTO

The following table presents tabular data concerning irrigated acres that are affected by water shortages.

Table V-1.--Irrigated acres with problems

	(1000 acre-units)			
	Water Supply	Off-Farm Conveyance Systems	On-Farm Systems	Management
Arizona	3.4	4.0	8.2	10.0
Colorado	102.1	132.0	123.5	155.7
New Mexico	6.3	16.2	28.0	28.0
Utah	3.3	3.0	5.0	6.0

Source: Water Conservation & Salvage Study, U.S. Department of Agriculture, 1973.

Potential projects of the U.S. Department of Agriculture and the Bureau of Reclamation to alleviate the water shortage problem and increase agricultural output are described in Chapter IX.

Table V-2.--Irrigated acreage by state, San Juan River Basin, 1965
(unit-1000 acres)

	IRRIGATED CROPLAND				
	Full Supply Land 1/	Short Supply Land 2/	Full-Short Supply Total	Idle Land 3/	Total
Arizona	1.2	3.4	4.6	6.2	10.8
Colorado	107.7	60.6	168.3	18.4	186.7
New Mexico	38.5	6.3	44.8	8.1	53.2
Utah	1.7	3.3	5.0	1.1	6.1
Totals	149.1	73.6	222.7	34.1	256.8

1/ Full water supply land is land that has an adequate water supply.

2/ Short water supply land is land that has an inadequate water supply.

3/ Idle land is land which is not irrigated for various reasons in an average year.

Source: Upper Colorado Region Comprehensive Framework Study.

Rural-Domestic

The community of Towaoc within the Ute Mountain Ute Reservation has experienced an extreme shortage of water for many years for the 1,000 permanent residents. Drinking water is currently being hauled and at times during the drier months of the year, it is necessary to haul water to keep the sewage system operating properly. The town of Ignacio, Colorado and the tribal motel complex with related facilities operates under an old and inadequate system for present and future plans. The rural domestic water problem is usually one of developing water systems and improving water quality rather than lack of sufficient quantities.

SEDIMENT YIELD

Sediment, the product of erosion, is solid material that is being transported or has been moved from its site of origin. It causes many economic losses. Sediment deposited on farm land damages crops, clogs

irrigation and drainage ditches, impairs surface drainage, affects soil productivity, and makes land leveling or other repair operations necessary. Storage capacity of reservoirs is depleted due to filling, and mechanical equipment such as pumps and generators are damaged. Sediment destroys fish habitats and the aesthetic values of water and shorelines, thus impairing recreational opportunities. It also has a detrimental effect on water quality.

Sediment yield is the volume of sediment that is moved from its site of origin into local watercourses. It is a function of both the amount of gross erosion and the capability of the stream system to transport eroded materials. Sediment yield is usually expressed in acre-feet per square mile per year or tons per square mile per year. It may be expressed in terms of suspended sediment, bedload, or total sediment. Stream sediment stations usually measure only suspended sediment.

Sediment yield within the San Juan River Basin is governed by the interaction of a number of factors. 2/ They include geology, soils, runoff, climate, topography, ground cover, land use, upland erosion, channel erosion, and sediment transport. The impact of any single factor is changed by the combined effect of the others. Some of these factors such as geology and soils, climate and runoff, ground cover and land use, and upland and channel erosion are directly related and may be considered as paired influences. Their relative significance varies from place-to-place, but can be predicted in a general way by combinations of soils and cover types.

The Sediment Yield map following page V-6 shows the general location of the five sediment yield classes that were mapped in the basin. It can be used for general planning over a large area, but is not suitable for project planning. Diversions or storage of streamflow, such as at Navajo Dam, reduce a stream's sediment transport ability. Under conditions of reduced flow, sediment will accumulate in reservoirs, be diverted in irrigation water, or be deposited in stream channels and consequently, the map may not represent actual yields.

Table V-3 shows the acreage and percent of each sediment yield class in the basin by states.

2/ *The method used in this study is described in a report of the Water Management Subcommittee of the Pacific Southwest Interagency Committee entitled, "Factors affecting sediment yield in the Pacific Southwest area", October 1968.*

Table V-3.--Acreage of sediment yield classes and percent of area covered, San Juan River Basin in Arizona, Colorado, New Mexico and Utah, 1973

Sediment Yield Sq Mile Per Year		Acreage in Thousands of Acres & Percent									
		Arizona		Colorado		New Mexico		Utah		San Juan River Basin	
Acre-Ft	Tons	Acres	Pct	Acres	Pct	Acres	Pct	Acres	Pct	Acres	Pct
1.0-3.0	1500-4500	11.7	0.4	80.0	2.2	993.9	15.9	220.8	8.0	1306.4	8.2
0.5-1.0	750-1500	893.3	27.4	526.7	14.2	1182.1	19.0	1197.7	43.3	3799.8	23.8
0.2-0.5	300-750	1330.0	40.8	1265.9	34.1	3841.3	61.6	735.4	26.6	7172.6	44.9
0.1-0.2	150-300	1021.0	31.4	877.4	23.6	216.3	3.5	609.9	22.1	2724.6	17.1
< 0.1	150	0	0	961.8	25.9	0	0	0	0	961.8	6.0
Total		3256.0	100.0	3711.8	100.0	6233.6	100.0	2763.8	100.0	15965.2	100.0

LOCATION MAP

LEGEND

YIELD RATE
(Square Mile / Year)

ACRE FEET	TONS
1.0 - 3.0	1,500 - 4,500
0.5 - 1.0	750 - 1,500
0.2 - 0.5	300 - 750
0.1 - 0.2	150 - 300
< 0.1	< 150

Do not use for design purposes. Detailed study is required to obtain the sediment yield for a specific location.

SEDIMENT YIELD MAP

SAN JUAN RIVER BASIN

ARIZONA, COLORADO, NEW MEXICO AND UTAH

JANUARY 1974

10 0 10 20 MILES

SCALE 1:1,150,000

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-S-23191-N

Sediment from Canyon Largo, tributary to the San Juan River SCS PHOTO

A common condition throughout the rangeland of the basin is the occurrence of scattered streambank cutting and trenching in deep alluvial soils of the valleys. Bank cutting and trenching have major significance as they greatly increase the amount of sediment available for transport. These higher yielding areas are inclusions within broader delineations, since it was not feasible to show small local areas of bank cutting and trenching.

McElmo Creek in Colorado is an example of a stream with bank cutting that has been included within an area of lower sediment yield due to the narrow width and scattered locations of the bank cutting. Other examples are major tributaries of Gobernador Canyon, Canyon Largo, and Chaco River in New Mexico. Chinle Wash in Arizona along with Montezuma Creek and Cottonwood Wash in Utah also have scattered bank cutting that is not represented in the mapped sediment yield class.

Approximately 8.2 percent of the basin has an annual sediment yield ranging from 1.0 to 3.0 acre-feet per square mile. Most of the 1,306,000 acres of this class are in New Mexico, but there is some in the other states. Dominantly, the land in this class consists of eroded shale and soft sandstone areas that have shallow soils and sparse plant cover.

Areas with a yield of 0.5 to 1.0 acre-feet per square mile per year occupy 23.8 percent of the basin. Each state has land within this yield class, but New Mexico and Utah have the largest acreages. Most of the acreage is rangeland except in Colorado where a significant amount of dry cropland is included.

The largest part, or 44.9 percent, of the basin has an annual yield of 0.2 to 0.5 acre-feet per square mile. This class is widespread in all the states and is mainly rangeland although there is some irrigated cropland and forest land.

Areas with a yield of less than 0.2 acre-feet per square mile per year constitute 23.1 percent of the basin. They are composed mainly of forest land soils or deep, sandy rangeland soils. The largest acreage of this class is in Colorado and the smallest in New Mexico.

The suspended sediment load in the San Juan River is low as the river leaves the Colorado mountains but increases with distance downstream to the point where it joins the Colorado River. Of the total average annual sediment yield at Lee Ferry on the Colorado River for the years 1914-1957 about 38 percent came from the San Juan drainage. In 1962, records indicated that about the same percentage applied. Since then, actual delivery of sediment to Lees Ferry has been modified by the completion of several major reservoirs.

Data in Table V-4 compiled by the U.S. Geological Survey show that average annual sediment yields in the San Juan River near Bluff, Utah dropped markedly for the 1943-1952 and 1953-1962 periods as compared to the 1930-1942 period. The approximate annual 46 million tons of suspended sediment during the 1930-1942 period fell to 19 million tons in the 1943-1952 period and to 16 million tons during the 1953-1962 period.

Changes in a combination of several factors likely explain the reduction in suspended sediment in the river. Among the factors that may be responsible are a reduction in the magnitude and duration of flood flows, and a reduction in erosion as a result of the application of conservation land treatment measures. In addition, the valley trenches which are a major source of sediment may have reached their maximum channel area at many locations by 1942.

Table V-4.--Suspended sediment discharge, San Juan River Basin, 1965

Station number	River and location	Drainage Area Sq. Mi.	Period	No. Yrs.	Average Annual Runoff (Acre-feet)	Average Annual Suspended Sediment (Tons)	Average Annual Suspended Sediment Tons/ Sq.Mi.	Average Annual Suspended Sediment Ac.Ft. Sq.Mi.
9-3555	San Juan River near Archuleta, N.M.	3,260	1955-61	7	891,000	2,273,000 1/	698	
9-3565	San Juan River near Blanco, N. M.	3,560	1949-54	6	799,400	1,796,000	504	.35
9-3645	Animas River at Farmington, N.M.	1,360	1952-61	10	572,200	919,000	676	.42
9-3665	La Plata River at State line	331	A	-	27,900	28,000	85	.05
9-3680	San Juan River at Shiprock, N. M.	12,900	1952-61	10	1,448,000	10,510,000 1/	816	.51
9-3715	McElmo Creek near Cortez, Colo.	233	A	-	38,800	141,000	605	.37
9-3795	San Juan River near Bluff, Utah	23,000	1930-42	13	1,972,000	46,340,000	2,010	1.24
			1943-52	10	1,666,000	19,090,000	830	.52
			1953-62	10	1,492,000	16,200,000	704	.45
9-3800	Colorado River at Lees Ferry, Ariz.	107,900	1930-42	13	11,330,000	133,700,000	1,240	.77
			1943-52	10	12,500,000	80,000,000 2/	742	.45
			1953-62	10	9,980,000	56,320,000	522	.32
9-3820	Paria River at Lees Ferry, Ariz.	1,570	1948-65	18	17,790	3,536,000	2,250	1.41

A/ Estimated for water years 1914-57, adjusted to 1957 conditions; USGS Professional Paper 441

1/ Navajo Dam closed June 27, 1962

2/ Glen Canyon Dam closed March 13, 1963

Runoff, ground cover, and land use are the keys to the sediment problem as they determine the amount of upland and channel erosion. Reductions in sediment yield can only be achieved by the application of land treatment measures that affect them. Most of the higher sediment yielding areas in the basin are on rangeland so any significant reduction in sediment will depend upon rangeland management, treatment, and installation of structures such as those used for channel stabilization and sediment entrapment.

DRAINAGE

Many of the irrigated lands at the lower elevations are naturally well-drained. They occupy favorable topographic positions adjacent to natural drainageways, and the soils have sufficient permeability and depth for adequate removal of surplus water. Existing ground water tables in these lands remain at depths well below critical levels during the irrigation season without artificial measures. Drainage problems, however, have developed in irrigated areas where there are no natural drainage channels or escarpment outlets or where lands with fine-textured soils lie on slopes below coarse-textured higher lands being irrigated.

Some previously waterlogged tracts in the vicinity of Cortez, Colorado have been reclaimed into productive units and others remain undrained. The impaired drainage results from abrupt changes in land gradient and the occurrence of a pronounced thinning and concurrent restricted capacity of the gravel aquifers due to undulating shale bedrock approaching or outcropping the surface. The subsurface materials are normally very permeable and respond well to drainage.

Drainage problems on the several small irrigation projects on the Indian reservations of Arizona and New Mexico are generally caused by improper water management. Problems commonly occur during periods of high runoff when the watertable of the cropland rises to within one to two feet of the surface.

Some drainage problem areas that have been in existence for many years have been transformed to permanent wetlands with dependent wildlife populations. In such cases, the benefits of drainage should be weighted against the loss of wildlife values.

WATER RIGHTS

Minimum Streamflows

Existing and potential diversions have, in the past, decreased and will in the future, decrease flows in many Colorado streams to a level where fish, wildlife and recreational values have been and will be severely damaged. Every use conflicts in some degree with the water for fish and wildlife. Current rate of growth resulting in more urban development, irrigation, municipal and industrial use, energy requirements and recreational land development all threaten to destroy the aquatic environment of natural streams, rivers and lakes throughout the basin.

Reserved Rights - Indian and Federal Lands

One of the principal concerns in Colorado, and in the San Juan Basin, which has a tremendous impact on water resource planning is the doctrine of federal reserved water rights. In the Eagle County Case or *Darrow-Eagle Case*, the United States Supreme Court sustained the contention that water rights claimed by the United States are subject to determination under general adjudication proceedings in the state courts.

As a result of this case, the federal government has now filed claims for water rights in all of western Colorado. The filing made by the United States, encompassing federal lands, excluding Indian lands, in the San Juan Basin was made in the U.S. District Court. In June 1973, a U.S. District Court judge ruled that the federal government should take its claims for water rights to the state courts. With reference to Indian lands, the U.S. in 1972, filed suit in district court of Colorado to have its rights and rights of the Ute Mountain Ute and Southern Ute Indian Tribes determined as to the use of the waters of the San Juan River and its tributaries.

Many of the federal claims appear to seriously jeopardize the existing system of water rights within the San Juan Basin in Colorado. Both the magnitude and multiplicity of claims cast an almost impossible burden upon the citizens in attempting to protect their individual rights. Claims by the federal government are indeterminate since the pleadings in the various cases fail to disclose the quantity of water which is being sought.

International Agreements and Water Quality

Another serious problem affecting Colorado and the San Juan Basin is the international agreement concerning the quality and delivery of water to the Republic of Mexico. As discussed earlier in the summary

of the Colorado River Compact, the quality of water delivered to Mexico was never considered a part of the Mexican Water Treaty. However, in the interest of international comity, the U.S. government has pledged its cooperation to the Mexican Government and has virtually guaranteed that the United States will furnish Mexico a certain standard of good quality water.

The state of Colorado is concerned that in order to meet the improved water quality in the Lower Basin, water projects now scheduled for implementation in the San Juan Basin may be delayed or indefinitely deferred because of water quality restrictions.

WATER QUALITY

The high quality water that is found in the high mountain streams are ultimately affected by a variety of natural or man-made things such as sediment, surface runoff, natural salinity, and irrigation return flows. These are a few that may impair beneficial use of surface water supplies.

Dissolved solids concentrations in high mountain streams may be less than 20 ppm. Some streams at the lower elevations such as the Mancos and LaPlata Rivers contain 500 to 1,000 ppm, especially in reaches downstream from irrigated land. At the present time, the water in the Mancos River, as it enters the Ute Mountain Ute Reservation, contains a high amount of dissolved solids preventing its use for irrigation or domestic purposes.

The Mancos River also carries a high concentration of suspended sediments which are detrimental to quality, as well as scenic beauty. McElmo Creek downstream from Cortez, Colorado has a dissolved solid concentration that varies between 2,000 and 3,000 ppm. The Pine River drainage has a high concentration of selenium which has caused adverse effects to some tribal members and livestock.

Groundwater on the Ute Mountain Ute Reservation is inadequate and of such poor quality that it cannot be used for domestic use.

FLOODWATER PROBLEM

Flash floods caused by intense summer thunderstorms continually washout irrigation canals and disrupt irrigation delivery service. A typical irrigation canal can cross several side drainages on its way to the irrigated land. Many of these crossings do not have adequate structures to protect the canal from floodwaters. Where floodwaters are allowed to enter canals, sediment is deposited reducing carrying capacity and increasing maintenance costs. Maintenance costs for removing sediment from canals are a major expenditure of some irrigation systems in the Pine River drainage.

The mainstem of the Animas River has caused damage to diversion structures, bank erosion, sediment deposition and river meandering.

The Mancos River has caused flood damages to bridges and numerous irreplaceable archeological sites. Floodwater damages have been experienced by urban areas such as Aztec, New Mexico and Durango, Colorado.

The town of Aztec, New Mexico is located near three small arroyos that can discharge floodwaters directly into the town. In August 1965, an estimated $92,000 of damage was caused by floodwaters from the three arroyos. The frequency of this event was estimated to be a 20 percent chance of occurrence. Lightner and Junction Creeks which have a combined drainage area of over 100 square miles caused an estimated $390,000 of damage in October 1972 to the city of Durango, Colorado which is located at the confluence of the two creeks with the Animas River. The expansion of the city upstream in the two narrow valleys will increase future damages.

Lightner Creek flood, October 1972
SCS PHOTO

MINING

Spoil Piles

Mining areas are more of a potential rather than an existing hazard to water or land resources. Spoil piles from uranium mills and gold and silver mines are a potential source of suspended sediment and radioactive water contamination. Wind and water movement from these piles is a continuing threat.

Strip Mining

Strip mining for coal to provide fuel for one of the world's largest coal-fired electric generating facilities is taking place in the area south of the San Juan River and west of Farmington, New Mexico. Large areas of land will be stripped to provide this fuel. The resulting rehabilitation of these strip areas will be a continuing problem in this semiarid region. Sediment production, wind erosion, reestablishment of plant cover, and overall degradation of the quality of the basin's environment would be the major problems associated with large scale strip mining.

Petroleum

Oil and gas production and exploration proceeded at a rapid pace in this basin in the two decades following World War II. Individually the wells, pumping plants, and associated facilities take up only a small amount of land, the wells only a fraction of an acre each. Their effect on land use is not noticeable. Oil and gas spills and releases of salty water from drilling operations are industry hazards which are potential problems. Presently, the existing fields are on more of a production than a development basis, which somewhat lowers the risk of soil and water contamination. Scars relating to development activities in the oil and gas fields are beginning to show the effects of revegetation and normal land use.

RECREATION

Many problems are associated with the quality and quantity of resources available to meet present and future recreation needs. Several are listed as follows:

1. Lack of funding recreation development. In order to provide for an anticipated increase in recreation, new methods of funding will be needed to finance facilities and access to recreation areas.

2. Lack of access. The lack of legal and physical access to many lands have decreased over time as the increase of public use of recreation increases. Many prime fishing and hunting lands have been purchased to prohibit public access.

3. Capacity of resources to support recreation. Many resources at present, exceed their capacity to support recreational activities in maintaining a desired level of quality as well as quantity. Pollution from sewage and industry has been confined to local areas. However, projected development would soon become a serious problem. Certain environmental values associated with recreation are being lost as a result of vegetative control, lack of effective flood plain management practices and improper use of trail vehicles.

FOREST LAND PROBLEMS

Forest land problems can be placed into several categories.

Range and Forest Fires

The national forest portion of the basin has averaged 61 fires per year with an average burned acreage of 132 acres per year for the 5-year period 1964-1968, Figure V-1. Of these 304 fires, 98 fires were man-caused and 206 fires started from lightning. The average area burned annually is 658 acres. There has been a slight decrease in the number of man-caused fires during the last few years. This trend is undoubtedly due to the fire prevention activities of state, Indian, and federal forest land managers.

Although the incidence of fires is low, there is a high potential for fire. Serious situations occur in the summer when high fire danger coincides with peak human use. Large fire scars north of Durango are evidence that catastrophic fires can occur. Primary detection is accomplished through fire lookouts and planned aerial patrols. Fire cooperators, forest permittees, forest residents, recreationists, and roving patrols make up a secondary ground detection system.

The danger of man-caused fires will increase as uses of forest land and adjacent land is intensified. Reduction in grazing use and increased slash from timber harvest can be expected to increase the risk in the future. It is believed that fire occurrence will increase 50 percent by 1980, and double by 2000. The Durango airplane slurry base has proven effective and is being used as the initial attack on many fires prior to ground crew arrival. Initial attack by air tanker is used whenever it is considered necessary.

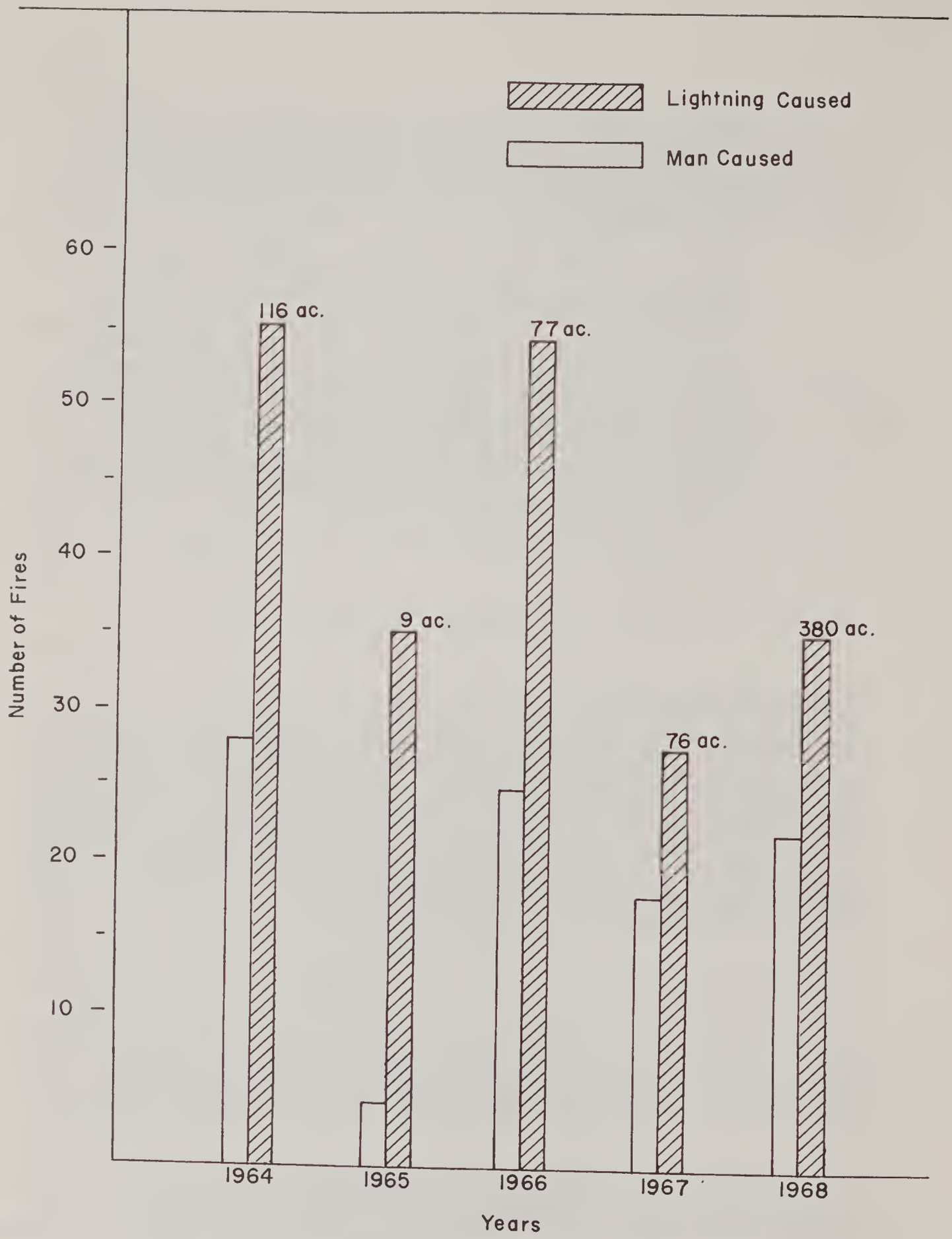


Fig. V-1. Fire occurrence, 1964-1968, national forest lands, San Juan River Basin in Colorado, New Mexico, and Utah.

Fire damage frequently permits disastrous insect and disease invasion in forested areas. It also results in erosion damage, increased sediment and floodwater production, sediment deposition, and the destruction of foreage production required for both domestic livestock and wildlife. Serious economic losses are caused to forest industries, forest dependent communities, and range operators. The public is affected through loss of the resources and economic values, and by the loss of access to fishing streams, lakes, and other recreation areas.

Forest Insects and Diseases

Insects and diseases cause economic and aesthetic losses through mortality, growth reduction, and deformities which lower wood quality. The effects of forest pests vary with the age and condition of forest stands and with the intensity of forest management being applied.

Because of extensive areas of mature and overmature spruce, the spruce bark beetle is potentially the most damaging pest. Windstorms often blow down large areas of spruce. The fallen timber can become a breeding area for spruce beetles which spread rapidly to adjacent standing trees. These occurrences are not predictable, but there is a history of severe epidemics of this type in the basin.

Another insect which has caused problems in the past is the mountain pine beetle which attacks mature and overmature ponderosa pine. As these older stands are cut and with thinning of young stands, the losses due to this insect will decline.

The insect has been most damaging in mature and overmature ponderosa pine. As these stands are cut over and placed under silvicultural management, the mountain pine beetle losses have declined.

Several other insects are present in the basin, but they are not causing significant losses. In time, as conditions change and mature stands are replaced by young trees and as plantations occupy proportionally larger areas of the forest land, new insect problems will arise.

In this perspective, it is not the insect but rather the condition of the stand in which the insect occurs that is the problem. The primary problems which can cause insect losses are overmaturity of trees, lack of accessibility, cutting patterns which do little to reduce windthrow, and delay or neglect of salvage logging in windthrow areas.

The primary tree diseases, like insects, are found in mature and overmature trees. The stand condition is the problem, the diseases are merely symptoms. At the present time, western red rot and root rot on ponderosa pine and dwarf mistletoe on ponderosa pine and Douglas fir are causing growth loss, mortality and losses in timber quality.

Forest Management

The condition of most timber stands must be improved to meet future demands. Projections of timber resources, its volume and condition to the year 2020 have various aspects of speculation and conjecture. Over the next 50 years, a number could influence the timber resource. An immediate program of timberstand improvement to rehabilitate the forests would significantly affect the volume produced while an influx of forest industry using wood pulp and fiber would also affect projections. A change to use of other substitute products for forest products would certainly influence forest management activities.

If the basin is to meet its share of projected timber demands, the following problems must be solved:

1. More roads must be built and other roads reconstructed to utilize areas of overmature stagnating stands of timber and to improve opportunities for protection, thinning, and other stand improvement measures.

2. A vigorous marketing program, including research, is necessary to better utilize the basin's existing timber resource.

3. Utilization studies leading to improved practices are necessary to insure greater efficiency in timber use.

4. Timber management must become increasingly intensive, especially with respect to old-growth conversion, and improving the number, spacing, vigor, and age-class distribution of trees.

5. There is a need for more intensive surveys to develop management plans; more research; better protection from fire, insects, and disease; more thinning and other stand improvement measures; and prompt regeneration.

6. Development of the timber resource must be geared to multiple use management.

FISH AND WILDLIFE RESOURCE PROBLEMS

Fish Resources

Problems which affect maintenance of stream and lake habitat include periodic low flows, flash floods, pollution from mines, excessive sedimentation, and excessive nutrient levels.

These problems reduce the fishing opportunity by reducing carrying capacities of the basin's waters, destroying or reducing fish spawning areas, and in some cases, killing the fish. The quality of sport fishing as a recreation is also seriously affected. Arizona and New Mexico appear to be the most seriously threatened states. Demand for fishing in the two states is expected to increase 207 percent by 2020. The projected demand will exceed the supply or fishing capability by 124 percent in Arizona and by 540 percent in New Mexico in 2020. Colorado and Utah appear to have sufficient fishing capability to satisfy demand if streams and lakes are maintained at the current level of quality.

Specific problems that could have a significant impact on fishing supply are:

1. Blanco River, Colorado, below the diversion point of the San Juan-Chama Project. The river has periodic periods of low flow, usually late in the summer. The San Juan-Chama Project diversion has substantially lowered the level of late season flow especially in the stream west of Highway 84. Lack of water, increased temperature, and uncertainty of flow has caused the Division of Wildlife to suspend stocking operations in this portion of the Blanco River. The river was not a high quality stream prior to the diversion, so loss of the fishing is not a major problem. It does affect local fishing opportunity.

2. Flash floods, Animas River, Colorado; San Juan River, McElmo Creek, Colorado. The soils and topography of the watersheds and precipitation patterns combine to periodically damage the fishery of these streams and others in the basin. Floods change stream courses, destroy fish nesting areas, fill-in deep streambed holes, and physically sweep fish away.

3. Acid mine drainage, Animas River and Florida River, Colorado. Extensive mining and ore processing activities in the headwaters of these rivers and other smaller streams discharge toxic metals, chemicals, and acids. Algae, bottom organisms, and fish are killed or damaged. The level of mining activity has been low in the past several decades, but increased interest due to shortages and higher prices is stimulating new activity. This problem could become severe in a short time.

4. Sedimentation - all major rivers and streams. Natural sedimentation is common to many streams. Sediment is degrading streams due to many causes. Industrial activities, heavy grazing by domestic and wild animals,

urbanization, general mining, housing development, highway construction, and agricultural uses are contributing to the problems. Sediment affects oxygen levels, temperature, water depth, eutrophication rates, and pesticide levels.

5. Access for fishermen is a problem throughout the basin. Where shorelands and streambanks are privately owned, many fishermen are excluded. Thus, the supply or fishing capability may be high enough to satisfy demand, but because the general public is excluded, there is still a large need or unfulfilled demand.

Wildlife Resources

Problems reducing the supply or hunting capability stem primarily from conflicts in land use. Large areas of wildlife habitat are well suited for other uses which compete with wildlife. The competitive uses often provide a quick and direct benefit to the landowner, while wildlife benefits, though often much greater, do not accrue directly to the landowner. This usually results in wildlife uses being relegated to second place.

In spite of accelerating wildlife management programs, wildlife resources will probably remain at current levels. Competitive land uses and increasing hunter demand will probably offset management efforts.

Demands on wildlife resources, especially hunting, can probably be met in Colorado and Utah if habitat quality and quantity is maintained. In Arizona and New Mexico, there are no current surpluses of wildlife and it appears that future demands will not be met. Reductions of habitat area or of quality will compound the shortages in these states.

Specific problems affecting wildlife supply are:

1. Elk and deer winter range reductions in Colorado and New Mexico. New subdivisions, urban developments, summer homes, and recreation developments, such as winter sports areas and golf courses are steadily encroaching upon elk and deer winter habitat. These developments occupy large areas of critical habitat and physically block big game movements to thousands of acres of range. The problem is most severe in the areas around Durango, Colorado; along U.S. Highway 160 between Durango and Pagosa Springs and Arboles, Colorado; and along U.S. Highway 550 from Durango north to Molas Divide. The ponderosa pine-Gamble oak forest type, particularly the south-facing hillsides and valley bottoms, are prime winter range in this area. These

same areas are very attractive real estate and recreation developers because they are low elevation, have relatively gentle slopes, and access is very good. Large increases in the human population are expected and this will increase the habitat loss. At the present time, local planning commissioners and county boards are trying to minimize the effects of development, but there are no zoning regulations or laws which allow development permits and subdivisions to be denied on account of wildlife.

2. Access for hunters is a problem in some areas. The distribution of hunters is controlled in large part by the closing of private lands and by the transportation system on public lands. The harvest of big game, particularly in Colorado, may be less than desirable because hunters cannot easily travel into areas where game is concentrated. The lack of access and the large areas of undeveloped land or wilderness has not affected wildlife improvement of game management agencies.

3. Following construction, large water development projects and diversions such as Navajo Reservoir and proposed McPhee Reservoir under the Dolores Project are inundating some areas which are important as winter range. Although the Dolores water distribution systems now planned as buried pipeline, large open main canals which transport water to irrigation areas can block access and migration routes. Some of the most damaging effects of water development are the associated developments such as marinas, homes, condominiums, and roads. A secondary effect of water development is conversion of range or brush land to irrigated cropland. This causes some losses of habitat and results in game damage to crops.

4. Wild turkeys are an important game species. A major problem is that they are easily domesticated and readily abandon the wild state for dependence upon man.

   Turkey habitat roughly coincides with elk and deer winter range described above. The impacts of development will reduce the area of habitat and throw turkeys in closer contact with man. The overall effect is a reduction of wild turkey supply. Another problem is that turkeys tend to group themselves in relatively small areas leaving large areas of suitable habitat unused. Trapping and redistribution programs could help this problem.

5. Weather modification programs could be a potential problem. The results so far are inconclusive, but if effective, serious impacts on wildlife could occur. Specifically, if snow depth were increased on winter range, this could force animals onto smaller areas, into urban developments and onto croplands. The net result could be reductions in wildlife numbers and decreased quality.

EROSION AND SEDIMENTATION

Local sediment damage is a problem, especially on very steep, low elevation forest land. Roads, trails, and over grazing are major causes of accelerated sediment production in these areas. Off-road travel and undesired use of old roads by four-wheel drive vehicles, trail bikes, and similar vehicles are causing severe damage to forest land in localized areas.

Range over-use and resulting deterioration is mostly a problem of livestock distribution rather than excessive numbers.

Gully erosion U.S. FOREST SERVICE PHOTO

VI. PRESENT AND FUTURE NEEDS FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT

IRRIGATED CROPLAND

The RI-OBERS projected population increase in the basin along with an anticipated increase in per capita consumption of red meat will require an additional 206,400 acres of irrigable land. The irrigated land will be required to provide food for population growth as well as forage and feed for the projected increase in livestock numbers.

Table VI-1 shows in tabular form, the present and projected irrigated crop distribution. The largest acreage increase will be required for alfalfa and rotation cropland. The table shows anticipated increases in crop yields through new knowledge and technology not currently available. Considering the increased yields per acre and the projected acreage, an additional 330,000 tons of hay and 748,700 animal unit months of forage will ease the rangeland grazing pressure.

About 200,000 of the 206,400 acres of additional irrigated land required are contained within the Bureau of Reclamation's proposed Dolores and Animas-LaPlata projects currently under advanced planning and the Navajo Irrigation project currently under construction.

The above projects along with other proposed projects summarized in Chapter IX include sufficient land and water requirements to meet projected needs of the basin.

WATER NEEDS

Projected water depletions associated with projected levels of economic activity were developed in Chapter IV. There is adequate water in the region to supply projected depletions - if storage and distribution facilities are available. Without adequate storage and distribution facilities, projected levels of agricultural development will not be met and agricultural water may be shifted to mining, power generation, and other municipal and industrial uses. This may be accomplished by purchase of water rights or purchase of both land and associated water rights by nonagricultural sectors.

Controlling the water quality of return flows from future water developments should be included in the planning and implementation process.

Projected water needs are shown in Table VI-2 for the time frames of 1980, 2000, and 2020. The projections are based on the regionally interpreted OBERS requirements as developed for the Upper Colorado River Region Framework Study. Some modifications were made to the data as it

Table VI-1.--Present and projected irrigated crop distribution, yields and total production, San Juan River Basin 1/

Crop	Distribution (1000 Acres) Present	Distribution (1000 Acres) Projected	Units per Acre	Yield Present	Yield Projected	Units 1000	Production Present	Production Projected
Hay								
Alfalfa	54.4	114.0	Ton	2.5	4.0	Ton	136.0	456.0
Other Hay								
Improved	10.6	8.7	Ton	1.3	2.4	Ton	13.8	20.9
Native	10.0	10.4	Ton	0.75	1.0	Ton	7.5	10.4
Subtotal	75.0	133.1					157.3	487.3
Pasture								
Rotation (cropland)	37.1	149.8	AUM	3.1	5.7	AUM	115.0	853.9
Permanent (non-cropland)	36.1	37.1	AUM	1.8	1.8	AUM	65.0	66.8
Other (non-cropland)	40.2	40.2	AUM	0.6	0.8	AUM	24.1	32.2
Subtotal	113.5	227.1					204.2	952.9
Corn silage	10.3	15.0	Ton	15	24	Ton	154.5	360.0
Feed Grains								
Oats	4.2	3.0	Bu.	42	60	Bu.	176.4	180.0
Barley (excludes Moravian)	5.2	14.7	Bu.	45	67	Bu.	234.0	984.9
Corn	2.0	6.5	Bu.	74	116	Bu.	148.0	721.5
Subtotal	11.4	24.2						
Other Grains								
Barley (Moravian)	N/A	9.0	Bu.	N/A	61	Bu.	N/A	549.0
Wheat	6.5	18.0	Bu.	30	53	Bu.	195.0	954.0
Subtotal	6.5	27.0						
Other Crops								
Orchard	3.1	3.1	Ton	4.4	9.9	Ton	13.6	30.7
Dry Beans	0.5	4.1	Cwt	19	21	Cwt	9.5	86.1
Truck Crops	1.8	1.8	Cwt	75	159	Cwt	134.3	286.2
Potatoes	0.7	0.9	Cwt	234	320	Cwt	163.8	288.0
Subtotal	6.1	9.9						
Idle Land	34.1	26.6						
Total	256.8	462.9						

1/ Upper Colorado Region Task Force data, adjusted to San Juan River Basin boundary

Table VI-2.--Projected water use needs (acre-feet)
San Juan River Basin

Type of Use	Colorado	New Mexico	Arizona	Utah	TOTAL
			1980		
Irrigated Crops 1/	283,000	245,000	7,000	56,000	591,000
M&I 2/	10,000	8,800	4,300	1,600	24,700
Electric Power		55,700	34,100	36,000	125,800
Minerals	1,700	3,700	400	1,900	7,700
Augmented Fish & Wildlife	17,400	6,800	1,200	400	25,800
Recreation	100	100	100	100	400
Export	2,500	117,500		500	120,500
Total Depletions	314,700	437,600	47,100	96,500	895,900
			2000		
Irrigated Crops 1/	341,000	329,000	7,600	71,000	748,600
M&I 2/	14,200	13,900	6,500	2,100	36,700
Electric Power		106,800	34,100	72,000	212,900
Minerals	1,800	3,900	300	1,800	7,800
Augmented Fish & Wildlife	17,400	6,800	1,200	400	25,800
Recreation	100	100	300	500	1,000
Export	2,500	117,500		500	120,500
Total Depletions	377,000	578,000	50,000	148,300	1,153,300
			2020		
Irrigated Crops 1/	360,000	411,000	9,000	105,000	885,000
M&I 2/	20,600	21,300	9,000	3,400	54,300
Electric Power		106,800	30,100	72,000	208,900
Minerals	1,600	2,600	300	1,100	5,600
Augmented Fish & Wildlife	17,400	6,800	1,200	400	25,800
Recreation	300	200	400	200	1,100
Export	2,500	117,500		500	120,500
Total Depletions	402,400	666,200	50,000	182,600	1,301,200

1/ Includes consumptive use, incidental use and appropriate reservoir evaporation.

2/ Includes stockpond evaporation and livestock use.

Reference: Upper Colorado River Region Comprehensive Framework Study.
Note: The figures in this table will not necessarily check with those given in Table IV-5, Historical Water Supply and Depletions, since that table is compiled for the San Juan economic region rather than the San Juan River Basin.

pertained to the San Juan Basin. This was due to the difference in the boundary location in Arizona and Utah for the framework study versus the River Basin Type IV study.

By the year 2020, the water needs within the basin will be 1.18 million acre-feet. In addition, the predicted export will be 120.5 thousand acre-feet with a residual river outflow of 1.08 million acre-feet (includes 227.6 thousand acre-feet of import), see Table VI-3. The irrigated crop needs will amount to about 37 percent of the basin water supply with municipal and industrial use 2 percent, electric power 9 percent, minerals 0.2 percent, fish and wildlife 1.1 percent, recreation 0.05 percent and basin export 5 percent. The projected export water would be transferred from the San Juan Basin in Colorado to the Rio Grande Basin in New Mexico.

Irrigated agriculture will remain the predominant user of the water resource. The projected increase of irrigated land will be from 256.5 thousand acres in 1965 (including idle land) to 462.9 thousand acres in 2020. Depletions from other combined types of uses, including basin export amount to about 47 percent of that for irrigated crops (for 2020).

SEDIMENT CONTROL

The more sparsely vegetated rangeland will continue to be the producer of the sediment loads in the basin. Limited annual precipitation causes restricted growth of vegetative cover. Water intake rates of soils are directly related to the amount of both new and old vegetative cover present. Also, the rain pattern includes occasional high intensity storms over limited areas.

With the low intake rates and a scarcity of dense growing plants to slow down water movement, silt production will be locally very high. Development of gullies allows for concentration of flows at even higher velocities and the acceleration of the erosive power of the water. Natural revegetation of the eroded areas is slow, and the eroded areas tend to become cumulative under these conditions.

Canyon Largo, Chaco River and Chinle Wash have large drainage areas which are considered to have high sediment production. These three drainages provide most of the natural drainage for the south half of the San Juan River Basin, yet as a percentage of the total water production of the basin, their combined contribution is small. The smaller drainages, north of the San Juan River in both Colorado and Utah, are also silt producers and need special attention.

Soil and water conservation practices are adaptable to the rangeland in these areas. The need is to conserve the precipitation in place in order that vegetation may make use of it. An increase in the amount of both live and dead vegetation increases the soil infiltration rate and

Table VI-3.--Projected Water Supply (acre-feet),
San Juan River Basin

	Time Frame		
	1980	2000	2020
Average annual supply	2,158,500	2,158,500	2,158,500
Import 2/	227,600	227,600	227,600
Depletions 1/			
Colorado	312,200	374,500	399,900
New Mexico	320,100	460,500	548,700
Arizona	47,100	50,000	50,000
Utah	96,000	147,800	182,100
Total	775,400	1,032,800	1,180,700
Export 1/	120,500	120,500	120,500
Residual outflow	1,490,200	1,232,800	1,084,900

1/ Data based on Upper Colorado River Region Comprehensive Framework Study. Colorado River Main Stem reservoir evaporation is not included.

2/ Imported from Dolores River Basin. Present 100,700 ac.ft. plus Bureau of Reclamation-Dolores Project, 126,900 ac.ft.

thus, lowers the amount of runoff. Proper livestock stocking rates and forage utilization maintain the essential plant cover to lessen the amount of soil movement. Rotation grazing and seasonal adjustments are essential. Other conservation measures include contour furrowing, pitting, contour seeding of adapted grasses, brush control, water-spreading, gully control, revegetation, fencing, stockpond construction, and installation of livestock water facilities.

Beef cattle and stock water pond

SCS PHOTO

The Bureau of Indian Affairs, Forest Service, Bureau of Land Management, Extension Service, Soil Conservation Service, and state and private landowners all have, or have knowledge of, study areas and treatment programs that make use of the practices mentioned above. In the past, emphasis has been on improving the grazing resource. With water pollution control emerging as a pressing need, even more emphasis can be expected to be placed on combinations of practices that provide for sediment control. Fortunately, one purpose compliments the other.

DRAINAGE IMPROVEMENT

As pointed out in Chapter III most of the presently irrigated land uses water of a good quality and the potential for salt pickup from the soil profile is not high. A major exception to this generality is the irrigated land which drains into McElmo Creek. The water supply for this area is from the Dolores River Basin and has a low

(125 ppm) weighted-average concentration of dissolved solids. This importation amounts to about 100,700 acre-feet annually. Table III-20 shows weighted-average concentrations of nearly 2,200 ppm on McElmo Creek near Cortez, Colorado. At this station, the flow is mainly return water from irrigated land. At the lowest flows the concentration may exceed 5,000 ppm. The drainage basin of McElmo Creek is underlain principally by rocks of Cretaceous Age, mostly shale, and is high in soluble materials. The high concentrations of dissolved solids in McElmo Creek then represent the drainage water pickup of salts while moving as groundwater in contact with soluble materials, and also from leaching through the soil profile.

The projected additional irrigated land will have good quality of water for irrigation. Adequate drainage will be needed to pregent excessive salinity buildup. The salinity in the root zone of the crops being grown must be kept in the range which the crops can tolerate. With adequate drainage, leaching can safely be a part of the irrigation water management program. The needed drainage in both presently irrigated and in additional irrigated areas can be accomplished by a combination of individual and group action type projects. Public Law 566 projects, especially those for agricultural water management, should include provisions for water table control and removal of excess irrigation water. The need to control the quality of return flows should also be a goal to be achieved. The same applies for irrigated land management and treatment programs for the individual farms or ranches.

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

Principal communities and towns are served by municipal water systems. A few of the people living outside of the communities pipe water from springs and wells or haul it from a nearby source.

Many of the municipal systems need improvement as well as water treatment. To keep pace with the growing population and projected demands, planners and/or governing bodies of the following communities and towns have expressed the need to improve their municipal systems:

- Colorado: Cortez, Dove Creek, Durango, Ignacio, Silverton, Bayfield and Towaoc

- New Mexico: Aztec, Farmington, Fruitland, Kirtland, Shiprock and Waterflow

- Utah: Eastland and Monticello.

Water supplies are sufficient to meet the present industrial needs, however, projected growth will require additional water. This is especially associated with further development of the basin's mineral resources. There are extensive deposits of bituminous coal which can be stripmined for large scale steam-electric powerplants. These powerplants would be interconnected with regional power systems. Expansion of gas, oil, and other industries such as petrochemical plants will also require additional water.

Use of surface water sources will be the most common means of meeting municipal and industrial water needs. Proposed federal multipurpose water supply projects such as the Bureau of Reclamation's Animas-La Plata project would supply water in the Aztec-Farmington-Shiprock, New Mexico and Durango, Colorado areas. The Dolores project would provide for the Cortez-Dove Creek-Ute Mountain Ute areas.

RURAL DOMESTIC AND LIVESTOCK WATER SUPPLY

Rural domestic water supplies for present needs are generally adequate except for the people living on or near the Indian reservations. A significant portion of the Indian population (especially the Navajo Reservation) has an inadequate water supply. In some cases, it is necessary to haul water from nearby sources to satisfy minimal requirements.

Both surface and groundwater sources are utilized to satisfy the rural domestic and livestock water requirements. In proportion to use, most of the domestic water supply comes from the groundwater aquifer whereas livestock relies heavily on the surface water resource. In general, the livestock water supply is adequate to meet most of the present needs, however, a better distribution of additional water developments is needed in some areas to help prevent overgrazing. Projected growth in the livestock industry will also require additional stockwater developments.

WATER QUALITY

By recognizing the present water quality problems and developing comprehensive plans, effective management of water quality and pollution control problems can be accomplished.

All agencies and organizations involved in making decisions about land and water resource use must continue to strengthen their programs for water quality management. This extends beyond those agencies specifically charged with pollution control - although the primary responsibility rests with them - to all governmental authorities having lesser interests or control over activities that affect water quality. Development of complementary and mutually supporiting programs by local, state, and federal agencies is needed.

In general, increased staffing of agencies is needed to adequately carry out the necessary programs. Federal grants are available to assist state and interstate water quality management programs.

The Water Quality Standards established by the states and approved by the Secretary of the Interior in accordance with the Water Quality Act of 1965 represent a major step in pollution control. The standards and their implementation plans are, in themselves, plans for controlling pollution. Expansion of the standards to include intrastate, as well as interstate streams is needed. Also, the water quality criteria should be expanded to cover additional parameters in order to provide a more complete measure of water quality.

The difficulty in maintaining or restoring water quality is continually increasing because of the growing quantity of effluents that are entering streams and the increasing depletions. Increases in pollution may result not only from population growth and industrial expansion, but also from intensification of water resources development. Although many situations can be met with existing knowledge, there is a continuing need for technological improvement in waste removal, treatment methods, and erosion control measures. In addition, there are situations for which the feasibility of solutions have not yet been determined. The control of salinity and mine drainage, for example, will require research and demonstration efforts to develop effective control measures.

Many of the earlier pollution surveillance programs were aimed at determining compliance with state regulations limiting the quality of effluents discharged to streams. Accordingly, data describing wastewater and stream quality conditions are limited. Expansion of present surveillance programs is needed in order to provide better stream coverage and to measure additional water quality parameters. A thorough knowledge of water quality conditions, waste loadings, and streamflow characteristics will permit the utilization of computerized mathematical modeling as a tool for better water quality management.

The greatest challenges to water quality management may not be those of a technical nature but could be the constraints imposed by existing legal and institutional arrangements. There is an increasing awareness that the problems of water quantity cannot be divorced from the problems of water quality. The search for solutions to the water quality problems defined herein must necessarily extend to an examination of existing legal systems and institutional arrangements to determine their effectiveness in implementing any proposed plan for the management of water quantity and quality.

The objective of these programs is to outline means to help maintain the quality of water at levels suitable to meet the criteria of the state-federal water quality standards. In the absence of water quality criteria for specific water uses or water-borne materials in the state

standards, the programs are based on recommendations for allowable amounts of potential pollutants that are delineated in several reference publications. Among these are the *Water Quality Criteria Report of the National Technical Advisory Committee to the Secretary of the Interior (66), Water Quality Criteria* by McKee and Wolf (70), and *Public Health Service Drinking Water Standards, (62).* 2/

From an evaluation of the present conditions of water quality and pollution control and the demands expected from future development, the following principal water quality management needs have been identified:

1. Improve salinity levels.
2. Improve wastewater treatment.
3. Streamflow management.
4. Abate pollution from mine drainage.
5. Control pollution from erosion of mining and milling solid waste piles.
6. Control thermal discharges.
7. Improve watershed management practices.
8. Reduce pollution from agricultural operations.
9. Control accidental spills of hazardous materials.
10. Prevent contamination of ground water.
11. Reduce sediment.
12. Control quality of irrigation return flows.

WATER RIGHTS

Minimum Streamflows

Colorado water development policy as expressed in the state constitution promoted the destruction of perennial streams and lakes in their natural state. The constitution provided for the maximum utilization of water resources by diversion.

Major and legitimate concern over this policy prompted the 1973 Colorado General Assembly to enact legislation redefining "beneficial use" of water. Under this legislation, beneficial use shall include the impoundment of water for recreational purposes, including fish and wildlife. Beneficial use shall also include the appropriation or acquisition by the state (Colorado Water Conservation Board) in the manner prescribed by law of such minimum streamflows between specific points or levels for and on natural streams and lakes as are required to preserve the natural environment to a reasonable degree. To implement this legislation, the Colorado Water Conservation Board, in cooperation with other appropriate state and federal agencies, should conduct studies and determine streamflow requirements and lake levels necessary for the preservation of fish and wildlife, recreation, aesthetics, and water quality in the streams, lakes and associated wetland habitat of the San Juan Basin in Colorado.

2/ *Upper Colorado Region Comprehensive Framework Study, Appendix XV, Water Quality, Pollution Control and Health Factors, pgs. 215-16, June 1971.*

Reserved Rights - Indian and Federal Lands

Colorado has two Indian reservations, both located in the San Juan Basin, occupying about 754,000 acres. Much of the land area is mountainous with about 280,000 acres in forests and 13,500 acres being irrigated for agricultural purposes.

Both reservations are experiencing municipal water problems; there is the desire for more irrigation development and there are developable coal deposits on reservation lands which currently are being evaluated by coal companies.

There is a critical need to determine the economic and social objectives of Colorado Indians and the associated water requirements so that water planning and development can be fully coordinated and compatible with the needs of the reservations and the state can administer the allocation and use of its water supplies.

International Agreements and Water Quality

Much concern has been expressed about the increasing salinity of the Colorado River. These problems extend to the Republic of Mexico and have become an important aspect in our international relations with that nation.

Salinity in the Colorado River and its major tributaries - in this case, the San Juan River - is generally not a serious problem in Colorado. However, Colorado sources do contribute to lower basin salinity problems. Of importance in this respect is McElmo Creek which contributes to the salinity concentration in the lower part of the Colorado River Basin.

Several measures now underway to reduce the salinity of the Colorado River should be continued. These include the Colorado River Water Quality Improvement Program. This program includes studies on irrigation improvement and management, point and diffuse salinity sources, economic analysis of water quality, analysis of legal and institutional matters, and investigation of potentials for improving water quality at points of diversion.

OUTDOOR RECREATION

Projected levels of recreation activity are shown in Chapter IV. Total recreation days were grouped into classes of recreation activity requiring developed land, undeveloped land, and water surface. Recreation standards were applied to projected recreation days for each class of recreation activity to obtain estimates of the demand for recreation

resources. These estimates of demand for recreation resources were compared with the recreation resource inventory of Chapter III to determine the need for recreation resources. Estimated recreation resource needs are shown in Table VI-4.

On a basin-wide basis, the capacity of the basin's recreational resources generally exceeds demand associated with projected recreational activity. Note however, that there still may be unmet local needs although a basinwide surplus of recreation resources exists. This is due to large quantities of recreation resources concentrated at relatively few locations some distance from local communities. The greatest need in the future will be for developed recreation land. Improved access to recreation resources will also be needed.

Trails provide wilderness recreation opportunity U.S. FOREST SERVICE PHOTO

Table VI-4.--Current and projected need for recreation resources, San Juan River Basin

Year	State	Need for developed recreation land, acres 1/	Need for undeveloped recreation land, acres 2/	Need for water surface acres 3/
1965	Arizona	491	0	0
	Colorado	0	0	0
	New Mexico	0	0	0
	Utah	0	0	0
	Total	491	0	0
1980	Arizona	4,103	0	0
	Colorado	0	0	0
	New Mexico	0	0	0
	Utah	0	0	0
	Total	4,103	0	0
2000	Arizona	11,845	0	11
	Colorado	3,140	0	2,242
	New Mexico	1,928	0	0
	Utah	887	0	0
	Total	17,800	0	2,253

1/ Developed recreation lands are those used for recreation facilities, roads, or other visitor improvements and land adjacent to facilities that receive intensive human use.

2/ Under-developed recreation lands are those that support developed areas by providing a scenic backdrop, that provide for extensive activities like hunting or hiking, or that are characterized by important wilderness,geologic or natural values.

3/ Water surface for swimming, boating, or waterskiing.

FOREST LAND DEVELOPMENT NEEDS

Projections of economic activity for the nation, region, and basin show a need to increase timber production. To meet the projected demands discussed in Chapter IV, production of timber will need to be increased by 13 percent in 1980, 44 percent in 2000, and 64 percent in 2020.

Tree planting or seeding is needed to reforest areas with low stocking as a result of fire, blowdown, and pest problems. This measure will reduce erosion and sediment, improve hydrologic conditions, and contribute to future timber supplies.

Spruce logs on the way to a plywood mill

U.S. FOREST SERVICE PHOTO

Sawtimber sized trees dominate stands on 1,030,000 acres or 71 percent of the commercial forest area. Most of these trees are 120 years old or older, and many are susceptible to insects and diseases. High risk trees - those not expected to live more than ten additional years because of insect and disease damage and other infirmities of old age - make up 26 to 50 percent of the stand on about 350,000 acres 3/ and on about 64,000 acres 3/, 51 to 75 percent of the trees are high risk. These conditions indicate the following needs: (1) prompt salvage logging in blowdown areas, (2) rapid and systematic application of the silvicultural cutting practices outlined in Rocky Mountain Forest and Range Experiment Station Research Papers, (3) access to remote and undeveloped areas (except those under study as potential additions to the National Wilderness Preservation System), (4) conversion of overmature stands to young stands, (5) intensive management and culture, such as thinning, pruning, and release of young stands.

Rangeland needs include improved herd and flock control and management, fencing, control of noxious and undesirable plants, and revegetation.

Recreation needs include expansion of developed recreation areas, development of new areas, protection of valuable archeological sites and cultural resources, improved and expanded access for recreationists, erosion control, and site rehabilitation in some developed areas and improved sanitation.

3/ *Risk class information extrapolated from a recent inventory and timber management plan of the San Juan National Forest to the commercial forest land of the entire basin.*

Table VI-5.--Estimated treatment needs for public and private forest lands, San Juan River Basin, Arizona, Colorado, New Mexico, and Utah, 1970

Item	Unit	Public Land Need	Private Land Need	Total Need
Watershed protection				
Sheet erosion control	Ac.	3,500,000	1,000,000	4,500,000
Gully control	Mi.	1,320	-	1,320
Fire control	Ac.	2,300	700	3,000
Flood & sediment damage control	Ac.	24,400	7,600	33,000
Timber production				
Initiate silvicultural systems	Ac.	1,240,000	190,000	1,430,000
Thin, prune or release	Ac.	124,000	5,800	129,800
Tree planting & seeding	Ac.	62,000	13,000	75,000
Range protection and improvement				
Grazing management	Ac.	2,500,000	4,000,000	6,500,000
Water development	Ea.	1,160	395	1,555
Fencing	Mi.	1,800	170	1,970
Plant control	Ac.	25,200	286,000	311,200
Revegetation	Ac.	3,800	246,000	249,800

Source: Upper Colorado Region Comprehensive Framework Study, Appendices VI, VIII, and XVIII, and Forest Service inventories and work plans.

VII. EXISTING WATER AND RELATED LAND RESOURCE PROJECTS & PROGRAMS

ECONOMIC RESEARCH SERVICE

The Economic Research Service has a responsibility to provide the economic analysis of the effects of alternative resource use in various aspects of the national agricultural life including: food supplies and costs, farm income, the cost of government programs, etc. The principal effort concerning the economic analysis of water and related land use is carried on by the Natural Resource Economics Division of the Economic Research Service. That Division carries out economic analyses and projections in river basin planning and conducts research on related subjects as required, including: water rights and related laws, water quality, watershed program analyses, outdoor recreation, land tenure and income distribution, rural zoning and other land use controls and employment and production effects.

SOIL CONSERVATION SERVICE

The Soil Conservation Service is the technical soil and water conservation agency of the U.S. Department of Agriculture (USDA). It is responsible for developing and carrying out a national program of conservation for land and water resources. The Soil Conservation Service (SCS) administers USDA activities involving technical and financial assistance for planning and executing programs to protect and improve water and related land resources in small watersheds. It gives technical information and services to other agencies in related programs as requested. The SCS cooperates closely with federal and state agencies that deal with loans, cost sharing, fish and wildlife, recreation, and other matters related to land and water use.

Public Law 46 Program

The Soil Conservation Service under the Soil Conservation Act (Public Law-46, 74 Congress 1935) carries on a broad program of direct assistance to farmers and ranchers through soil conservation districts, as well as aiding other agencies.

Related activities include farm and ranch planning and assistance in the installation of conservation practices, soil surveys and investigations, plant material improvements for conservation work, snow surveys and water supply forecasts, technical assistance to other USDA activities, and aid to other agencies responsible for administering conservation work on private lands. Forty-four soil conservation districts plan and carry out a program of soil and water conservation over most of the land (80 percent) in the region.

Public Law 566 Program

Public Law 566, 83rd Congress 1954, provides federal assistance to sponsoring organizations for planning and installing watershed projects. Watershed protection and flood prevention work is one of the programs carried on by the USDA through the administrative leadership of the Soil Conservation Service. This work combines soil and water conservation treatment on the land with control and use of runoff by means of upstream structural measures. Projects are planned for multiple use and conservation of all water and related land resources in a watershed. The SCS assists sponsoring agencies, such as soil conservation districts, and state or local governments in planning and executing the upstream watershed protection measures. The Forest Service, Farmers Home Administration, Bureau of Land Management, and other federal, state, and local agencies also give assistance in developing these projects. The land administering agencies are responsible for planning and applying treatment on federal lands within the watershed project. Cooperative USDA contributions to these projects are of three kinds: (1) technical assistance in planning, designing, and installing works of improvement and land treatment measures, (2) sharing costs of flood prevention and agricultural water management, public recreation or fish and wildlife developments, and (3) extending long-term credit to help local interests with their share of costs, including costs of developing industrial or municipal water supplies.

Public Law-566 Floodwater Retarding Structure
Pine River Watershed Project, Colorado SCS PHOTO

Resource Conservation and Development Program

A Resource Conservation and Development project is a locally initiated and sponsored activity to expand the economic opportunities for the people of an area by developing and carrying out a plan of action for the orderly conservation, improvement development and wise use to their natural resources.

All interests in an area -- rural, suburban, and urban -- work together to develop natural and related resources. Local people organize and apply through one or more legal sponsors such as a conservation district, a county governing body, or a town for assistance.

The U.S. Department of Agriculture, by authority of the Food and Agriculture Act of 1962, gives technical and financial help to local groups in the conservation and development of the natural resource in their area.

In Colorado, an RC&D project has been approved for planning on the San Juan Basin which includes all of Dolores, Montezuma, and La Plata counties in addition to portions of San Juan, Hinsdale, Mineral, and Archuleta counties that are in the San Juan River Basin study area. The RC&D area also includes a small portion of San Juan county, New Mexico.

In Arizona, the San Juan Drainage Area is included in the Little Colorado River Plateau RC&D Project Area which has been approved for planning.

Flood Hazard Analyses

Reports of flood hazards and other flood plain data are intended for use by states, municipalities, planning commissions, or other units of governments responsible for land use planning and regulation. The objective is to reduce potential flood losses which would otherwise be caused by unwise development of flood plains along streams and coastal areas.

The USDA carries out flood hazard analyses under authority of Section 6, Public Law 83-566, in accordance with Recommendation 9(c) of House Document No. 465, 89th Congress.

National Flood Insurance Program

The Soil Conservation Service cooperates with the Department of Housing and Urban Development in the National Flood Insurance

Program by furnishing information on frequency of flooding and extent of flood damages. In general this program, which makes flood insurance available at relatively low rates due to federal cost sharing, requires that appropriate flood plain regulations be adopted if a community or other political entity is to participate in the program. The SCS provides technical assistance to the community in meeting the requirements of the program.

Cooperative Snow Surveys

Snow surveys conducted by the SCS provide a means of water supply forecasting. More effective utilization of water is possible by having advance knowledge of seasonal and annual water supplies. Snow surveys have been conducted within the basin since 1930 with 12 snow courses in operation (10 in Colorado, 2 in Utah, and none in Arizona and New Mexico). In addition, one snow pillow in Colorado is contributing data. Regular forecasts are made monthly during the winter and spring and a "Forecast of the Water Supply Outlook" is published by the SCS. These are distributed to all water users, water resource agencies, and others who utilize these data. Appreciable assistance is provided by other public agencies, especially the U.S. Forest Service and the Bureau of Reclamation.

SCS Snow Survey

SCS PHOTO

Soil Conservation District Program

Soil Conservation Districts within the region have progressive action programs to provide conservation practices through cooperative agreements with farm and ranch operators. Through these agreements, private landowners are furnished technical assistance by the Soil Conservation Service for applying conservation practices. Additional assistance is furnished to irrigation and drainage districts, recreation groups, and rural communities. The U.S. Forest Service and the Bureau of Land Management also cooperate with the districts when public land is involved. There are six soil conservation districts serving the San Juan Basin portion of Colorado, three serving New Mexico, one serving Utah, and none in Arizona.

FARMERS HOME ADMINISTRATION

The Farmers Home Administration (FHA) was established to aid in the solution of rural and small community problems. The FHA offers a variety of loans which include:

1. Farm Ownership Loans to enlarge, improve, develop, refinance, or buy farms.

2. Economic Loans to Cooperatives to establish or expand cooperatives.

3. Economic Loans to Individuals for a maximum of $3,500 to help improve incomes of disadvantaged and low-income families in either agricultural or nonagricultural pursuits.

4. Grazing Association Loans to help groups of ranchers buy or lease tracts of land for joint grazing purposes.

5. Operating Loans for equipment, livestock, feed, fertilizer, seed, or refinancing farm debts other than real estate or buildings.

6. Rural Housing Loans to construct, repair, purchase, refinance, or modernize homes and farm buildings or to provide water for rural use.

7. Water Development and Soil Conservation Loans to develop, conserve, and make better use of soil and water resources on farms.

8. Watershed Loans to local organizations to carry out plans to protect, develop, and utilize the land and water resources in small watersheds.

9. Financial Assistance Loans to public or quasi-public bodies and nonprofit corporations that will serve residents of open country and rural towns (up to 5,500 population) for developing and improving domestic water and waste disposal systems.

10. Recreational Enterprise Loans to rural community groups or associations to finance recreational facilities and to family farmers to establish income-producing recreational enterprises. Recreational facilities financed include: (1) ponds, lakes, and picnic areas, (2) sports areas including golf courses and ski slopes, (3) camping facilities such as cabins, dining halls, sanitation facilities and roadways, (4) forest trails and natural scenic attractions, (5) fishing waters, (6) hunting areas and preserves, and (7) domestic water, irrigation, drainage or waste disposal systems in connection with recreational facilities. Loans for recreational enterprises to individuals are made only to farmers and ranchers who personally manage and operate family farms. The loan must also be used to develop an income-producing enterprise that will supplement their farm income.

The SCS cooperates with FHA by reviewing the technical phases of loan application that concern soils information, engineering design and layout, and other soil and water problems.

COOPERATIVE EXTENSION SERVICE

The Extension Service serves as liaison between research agencies, educational institutions, local, federal, and state agencies, landowners, and other individuals. It makes information and educational materials in improved crop varieties and livestock, land management use and practices, soil testing, and other similar problems relating to livestock, crops, range, farm management, and economics available to all groups or individuals who are interested.

County Agents in the San Juan River Basin are actively assisting in the identification and solutions of the water and related land resource problems and needs.

U.S. FOREST SERVICE

National Forest Water Resource Programs

Management objectives of ongoing watershed programs include:

1. Preservation or improvement of soil productivity.
2. Optimization of water quality and quantity, and timing of runoff.
3. Establishment of the right to use a sufficient amount of usable water to satisfy the long-term needs of the national forests.
4. Avoidance of pollution of return flows or impairment of downstream water uses.
5. Rehabilitation of damaged watersheds to restore soil stability, productivity, and proper hydrologic functions.

The Forest Service, through its Forest and Range Experiment Stations in Ogden, Utah and Fort Collins, Colorado, is carrying on research to improve watershed protection, increase water yield, and reduce erosion of forested lands.

Molas Lake, a multipurpose reservoir

SCS PHOTO

TIMBER RESOURCE PROGRAMS

The goal is an annual harvest, on a sustained yield basis, to meet the national forests' projected share of the nation's timber demands. Program objectives include:

1. Marketing the allowable cut on each working circle.
2. Reforesting nonstocked or poorly stocked forest land.
3. Developing and maintaining a complete transportation system.
4. Reducing the hazards of loss by fire, wind, insects, and disease through proper silviculture.
5. Maintaining proper stocking and growing conditions in young stands through timber stand improvement measures.
6. Controlling animal populations to the extent necessary to assure satisfactory regeneration and development of forest stands.

RANGE RESOURCE PROGRAMS

National forest lands provide forage for cattle, sheep, and saddle and pack stock used in managing the livestock and those used by recreationists. In recent years, livestock numbers and grazing seasons have been adjusted to bring use into line with range capacity.

Rangeland use and management has two major objectives:

1. Proper stocking and range improvement to achieve desirable watershed conditions and to sustain high level forage production.

2. Utilizing those areas which are suitable for grazing and encouraging development of range resources with due regard for other resources and values.

Programs for achieving the objectives include:

1. Range resource inventories and preparation of management plans.
2. Revegetation of overgrazed or damaged range lands.
3. Control of noxious or poisonous range plants.
4. Construction of fences and water developments needed for livestock control and to improve efficiency of forage use.
5. Coordination of range use with other resource uses.
6. Reconstruction or rehabilitation of deteriorated range improvements.
7. Elimination of livestock trespasses.

National Forest - Range Resource
SCS PHOTO

RECREATION RESOURCE PROGRAMS

Recreation on national forests is directed toward the best service of the steadily increasing numbers of people seeking relaxation in the outdoors. Facilities are designed to meet projected needs of local communities and the increasingly heavier needs of transient recreationists.

According to projections of the National Forest Recreation Survey, in conjunction with the Ourdoor Recreation Resources Review Commission, there are sufficient developed recreation areas to accomodate expected use to the year 2000.

Management objectives of ongoing recreation programs include:

1. Preservation and enhancement of a physical environment suitable for recreation activities.
2. Permitting visitors to participate in activities with a minimum of restrictions.

3. Establishment and maintenance of appropriate facilities and management of them to:
   a. Serve present and future needs.
   b. Prevent unsanitary conditions, water pollution, forest fires, and other resource damages.
   c. Insure safety of users.

The Forest Service has proposed addition of about 268,000 acres of land on the San Juan and Rio Grande National Forests to the Nation Wilderness Preservation System. The proposed wilderness would, if accepted, be administered in accordance with the Wilderness Act, Public Law 88-577, September 3, 1964. In addition, there are several roadless areas within the basin being reviewed to determine their suitability for study as potential wilderness areas.

WILDLIFE RESOURCES PROGRAM

The objective of ongoing wildlife programs is to provide fully productive habitat for fish, game and non-game populations. Wildlife habitat improvement is done cooperatively with state wildlife agencies. On the national forest, wildlife is favored to the extent possible without adverse effects on other forest uses.

The wildlife program includes:

1. Development of water supplies.
2. Improving stream and lake fish habitat.
3. Fencing to protect key food and nesting areas.
4. Creating wildlife openings in heavily forested areas.
5. Planting preferred tree, shrub and other plants for food and cover.
6. Salting to help control big game distribution.

STATE WILDLIFE MANAGEMENT PROGRAMS

The states have primary responsibility for managing and regulating fish and wildlife resources. Current action to meet needs and solve problems includes the following:

1. Purchase of winter game range and key areas needed to assure continuation of elk and deer herds at current levels. This program partially offsets the losses of habitat to subdivisions and other conflicting uses described earlier.

2. Purchase of lands or easements for fishing access. The aim is to provide satisfaction of demands for stream and river fishing in the face of increasing closures of private land.

3. Coordination with local and regional planning commissions and zoning boards. This will provide an appreciation and consideration of wildlife needs in county and regional land use. The purpose is to try to offset habitat losses and avoid developments which block wildlife access to winter range.

4. Restocking flood damaged streams. This is done to restore productivity to streams which suffer sudden damage from flash floods and debris flows.

5. Construction of catchments and other barriers to contain mine acids, sediment, and other pollutants.

6. Trapping and redistribution of wild turkeys to fully utilize suitable habitat. Openings and food plots in heavily forested areas are being developed in conjunction with the Forest Service to enhance wild turkey habitat.

7. Big game damage to crops and agricultural areas is being controlled by fencing, hazing with aircraft and pyrotechnic devices.

Cooperative State-Federal Forestry Programs

A number of ongoing forestry programs which contribute to needs of the basin are available through state-federal cooperation.

COOPERATIVE FIRE CONTROL AND PREVENTION

The Weeks Law of March 1, 1911 authorized the Secretary of Agriculture to enter into agreements with the states to *cooperate in the organization and maintenance of a system of fire protection on any private or state forest lands.* The Clarke-McNary Act of June 7, 1924 broadened and strengthened the provisions of the Weeks Law. Section 2 authorized extension of Cooperative Forest Fire Control to include all forests and critical watershed lands in state and private ownership.

The State Forestry Department provides the manpower and organization to do the job. The federal Forest Service provides services, training, and some funding. The two public agencies act as partners with actual administration of the program, supervision, and job implementation being carried out by the state agency.

The effort was strengthened by the Granger-Thye Act of April 24, 1950, which provides funds for erection of buildings, fire lookout towers and other structures on nonfederal lands.

COOPERATIVE FOREST MANAGEMENT

The Cooperative Forest Management Act of August 25, 1950 authorized Forest Service cooperation with state foresters and provided funds on a 50-50 basis for technical service to private forest landowners, operators, and processors of primary forest products. The goal is improved forest land management, harvesting, marketing, and processing.

General Forestry Assistance Funds are used to provide special forestry assistance not available through other Forest Service programs. The assistance is for the purpose of developing, managing and utilizing forest resources to contribute to economic development and environmental quality. The Forest Service makes and carries out a forestry plan for the project area. The federal and state agencies share responsibility for technical on-the-ground assistance and supervision of forestry measure implementation.

COOPERATIVE TREE PLANTING

Several federal programs authorize cooperation between the Forest Service, state foresters, and private landowners for reforestation. The major programs are:

1. Cooperative distribution of planting stock.
2. Soil bank.
3. Forestation assistance to states.

Under these programs private landowners may obtain tree seedlings from the State Foresters organization for windbreaks, shelterbelts, or forest plantations. The Clarke-McNary Act (Section IV) authorized the Forest Service to cooperate with the states in growing and distributing forest tree seeds and planting stock. Technical and financial federal assistance to states is authorized. The Agricultural Act of 1956 provides additional tree planting assistance through federal cost-sharing for site preparation, tree planting, and tree seedlings on state and private lands. Projects under this Act are formulated by the state forester to restock commercial forest lands.

COOPERATIVE WATERSHED PROGRAM

The Watershed Protection and Flood Prevention Act (Public Law 566) authorizes assistance to local groups to solve water-management and flood prevention problems. The program is cooperatively formulated and implemented by the soil and water conservation districts, state forestry agencies, the Soil Conservation Service, and the Forest Service. Technical assistance in gully and erosion stabilization, fire prevention and control, timber stand improvement, forest hydrologic improvement and other forest related watershed improvements are provided.

COOPERATIVE PEST CONTROL

The Forest Pest Control Act of June 25, 1947 provides for federal-state cooperation to protect and preserve forest resources from destructive insects and diseases. The Act authorizes the Secretary of Agriculture to act on federal land and to work with state foresters or other state officials on nonfederal land. Survey, detection, evaluation and control costs are shared by state and federal agencies.

VIII. WATER AND RELATED LAND RESOURCE DEVELOPMENT POTENTIAL

AVAILABILITY OF LAND FOR POTENTIAL DEVELOPMENT

Irrigated Cropland

Potentially irrigable lands in the San Juan River Basin, in addition to the presently irrigated acreage, comprise 3,595,700 acres. The lands suitable for irrigation development are widely dispersed throughout the basin. Many of these lands, although having soil, topographic, and drainage conditions favorable for irrigation, are located where water supply is insufficient or inaccessible at the present time, but may be conducive to development in the future. This 1965 irrigation land potential as extracted from Appendix X, Upper Colorado Region Comprehensive Framework Study, and adjusted to the San Juan Basin, is made up of 606,300 acres in Arizona; 245,400 acres in Colorado; 2,468,600 acres in New Mexico, and 275,400 acres in Utah.

There are many areas where irrigation proposals have been given some consideration. Suitable soils can be found in all of these areas, but water supply development can be expensive. Water supply development is limited by cost, compacts, and the remaining availability of water in each of the states.

Mining

Another anticipated use of land is for strip coal mining. This is presently a small operation, but expansion plans in the field of electric power generation may increase this considerably. Under the present low population density and with most of the area being used for grazing, it would appear that the basin could absorb a considerable amount of this type of land use without adversely effecting other land uses. Again, proper zoning to protect the recreational values should be the main concern. Plans for this type of land use should also include provisions for restoration of the areas after disturbance by mining.

Outdoor Recreation

Land available for recreational development is abundant to meet anticipated participation in the recreational activities studied. The recreation industry is a major factor in the economy of the basin and could be the principal determinant in elevating the economy of the basin.

Various federal, private, and tribal landholding administrators in the San Juan River Basin have suggested potential outdoor recreation areas for development. Tables VIII-1, 2, 3 and 4 list those suggestions. The accessibility and accompanying service facilities are generally nonexistent at many of these areas. The data developed in projecting future use indicates an increase participation in the 13 activities studied. If this participation is to be accounted for, interstate transportation planning should disperse accessibility in order that a quality recreation experience be maintained.

Capote Lake, a commercial fishing lake owned and operated by the Southern Ute Indian Tribe

SCS PHOTO

GROUND WATER

The potential for developing ground water resources is relatively low in the basin. Consideration of quality and economics will prohibit large scale development of ground water.

Table VIII-1 --Potential recreation resources, San Juan River Basin, Arizona

County	Type Area	Area - Name	Agency		Acreage			Bureau of Outdoor Recreation Class
			Present Ownership	Present Administration	Undeveloped Land	Developed Land	Water	
Apache	Scenic	Roof Butte - Beautiful Mountain	Tribal	Navajo-Shiprock	22,790	100	30	IV
Apache	State park	Four Corners Tribal Park	Tribal	Navajo-Shiprock	250	-	-	II
Apache	Historic Monument	Three Turkey Ruins	Tribal	Navajo-Shiprock	100	-	-	VI
Apache	Scenic	Carrizo Mountain	Tribal	Navajo-Shiprock	27,180	-	-	IV
Apache	Scenic	Chuska Mountain	Tribal	Navajo-Shiprock	2,500	-	-	IV
Apache	Scenic	Tsaile - Wheatfields	Tribal	Navajo-Chinle	-	-	-	IV
Apache	Scenic	Alcove Canyon	Tribal	Navajo-Chinle	27,120	-	-	IV
Apache	Scenic	Pena Blanca Canyon	Tribal	Navajo-Chinle	17,000	-	-	IV
Apache	Recreation	Four Corners High Density Recreation Area	Tribal	Navajo-Shiprock	100	-	-	II
Apache	Historic	Poncho House Ruin and Lower Chinle Cultural Area	Tribal	Navajo-Shiprock	15,000	-	-	VI

Source: Upper Colorado Region Comprehensive Framework Study, Appendix XII, Recreation, Adden. E-1

Table VIII-2.--Potential recreation resources, San Juan River Basin, Colorado

County	Type Area	Area - Name	Agency		Acreage			Bureau of Outdoor Recreation Class
			Present ownership	Present Administration	Undeveloped Land	Developed Land	Water	
Montezuma	Scenic	Sleeping Ute Mountain area	Tribal	Ute Mountain	35,200	-	-	IV
Archuleta	Recreation	Navajo Reservoir & Lake Capote Cabin Site areas	Tribal	Southern Ute	-	-	-	III
Dolores	Recreation	Monument Creek Reservoir	Federal	CGF&P	-	-	40	II
La Plata	Recreation	Animas Mountain Reservoir	Federal	USFS	-	-	251	II
La Plata	Recreation	Hay Gulch Reservoir	Federal	Local	-	-	374	II
La Plata	Recreation	Lemon Reservoir	Federal	Local	380	-	820	II
La Plata	Recreation	Haviland Reservoir	State	CGF&P	170	-	70	II
Montezuma	Monument	Chimney Rock	Tribal	Ute Mountain	-	-	-	II
Montezuma	Monument	Squaw and Papoose	Tribal	Ute Mountain	-	-	-	IV
Montezuma	Wild area	Rare Lizard area	Tribal	BLM	2,200	-	-	IV
Montezuma	Recreation	Narruguinnep Reservoir	Private	CGF&P	-	-	558	II
Montezuma	Recreation	Ruin Canyon Reservoir	Federal	CGF&P	-	-	163	II
Montezuma	Recreation	Cahone Reservoir	Federal	CGF&P	-	-	100	II
Montezuma	State Park	Four Corners Tribal Park	Tribal	Ute Mountain	250	-	-	II
Montezuma	Arch Site	McElmo Planning Unit	Federal	BLM	157,904	-	-	VI
La Plata	Recreation	Cinder Buttes Area - Three Buttes Res.	Tribal	Southern Ute	-	-	-	III
Montezuma	Scenic	West Mesa Verde Range area	Tribal	Ute Mountain	48,000	-	-	IV
Montezuma	Scenic	Eagle Eye Mesa - Big Mesa	Tribal	Ute Mountain	42,240	-	-	IV
Montezuma	Scenic	Ute Pasture area	Tribal	Ute Mountain	67,200	-	-	IV
San Juan	Historic	Animas Canyon	Private	State	-	-	-	VI
San Juan	Recreation	Animas Forks	-	-	-	-	-	II
San Juan	Primitive	San Juan Primitive Area	Federal	USFS	238,080	-	-	V
Montezuma	Historic	Hall's Trading Post	Tribal	Ute Mountain	-	40	-	VI
Various	Natl Scenic	Continental Divide Trail	-	-	800	-	-	IV
La Plata	Recreation	Pine River-Southern Ute	Tribal	Southern Ute	5,200	-	River	
La Plata	Recreation	Vallecito Ski area	Federal	USFS				
Archuleta	Recreation	Echo	State	DPOR				
Montezuma	Recreation	Spruce Lake	Federal	USFS				
Montezuma	Recreation	Mancos Canyon	Tribal	Ute Mountain				
Mineral	Recreation	East Fork Ski area	Private & Federal					
San Juan	Recreation	Molas Lake	Town of Silverton					

Source: Upper Colorado Region Comprehensive Framework Study, Appendix XII, Recreation, Adden. E-1

Table VIII-3--Potential recreation resources, San Juan River Basin, NEW Mexico

County	Type Area	Area - Name	Agency		Acreage			Bureau of Outdoor Recreation Class
			Present ownership	Present administration	Undeveloped land	Developed land	Water	
McKinley	Scenic area	Cleopatra's Needle-Venus' Needle	-	-	5,000	-	-	IV
Rio Arriba	Recreation area	Caracao Canyon Lake Site	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	Amargo Creek Lake Site	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	Honolulu Mesa Game Park Site	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	Wild Horse Mesa Game Park Site	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	Caracas Mesa Game Park Site	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Historic area	Otero Ranch Game Park and Historic Site	Tribal	Jicarilla Apache	-	-	-	VI
Rio Arriba	Historic area	Three Corn Site	-	-	-	-	-	VI
Rio Arriba	Historic area	Old Fort Site	-	-	-	-	-	VI
Rio Arriba	Recreation area	Navajo River Area	Tribal	Jicarilla Apache				
Rio Arriba	Recreation area	Dulce Lake Area	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	La Jara Lake Area	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	Gobernador	-	-	480	-	-	III
Rio Arriba	Historic Monument	San Raphael Canyon Ruins	-	-	640	-	-	VI
Rio Arriba	Recreation area	Lower Mundo Lake Area	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	Upper Mundo Lake Area	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	Pounds Mill Lake Site	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	Campanero Arroyo Lake Site	Tribal	Jicarilla Apache	-	-	-	III
Rio Arriba	Recreation area	Tapacito Arroyo Lake Site	Tribal	Jicarilla Apache	-	-	-	III
San Juan	Geological area	Bisti Badlands	-	-	-	-	-	IV
San Juan	Geological area	Fossil Beds	-	-	-	-	-	IV
San Juan	State park	Arch Rock	-	-	680	-	-	IV
San Juan	State park	Huerfano Butte	-	-	320	-	-	IV
San Juan	Local Recreation area	Meadows Reservoir	-	-	40	-	500	II
San Juan	State recreation area	Blancett	-	-	1,120	-	-	III
San Juan	State recreation area	Timbered Cone	-	-	960	-	-	III
San Juan	State recreation area	Nickerbocker Butte	-	-	1,280	-	-	III
San Juan	Scenic area	Ute Pasture Area	Tribal	Ute Mountain	22,400	-	-	IV
San Juan	Recreation area	Chuska Mountain	Tribal	Navajo - Ft. Defiance	49,920	300	60	III
San Juan	Scenic area	Roof Butte - Beautiful Mountain	Tribal	Navajo-Shiprock	29,660	200	-	IV
San Juan	Geological area	Valley of Volcanoes	Tribal	Navajo-Shiprock	28,000	2,000	-	IV
San Juan	Scenic area	Pena Blanca Canyon	Tribal	Navajo-Shiprock	10,700	-	-	IV
San Juan	Scenic area	Shoe Game - Teesnospas Canyon	Tribal	Navajo-Shiprock	700	-	-	IV
San Juan	Monument	Shiprock Formation	Tribal	Navajo-Shiprock	9,270	-	-	IV
San Juan	Recreation area	San Juan River - 54 miles	Tribal	Navajo-Shiprock	34,160	400	1,750	III
San Juan	Recreation area	Four Corners High Density	Tribal	Navajo-Shiprock	-	280	20	II
San Juan	Historic area	Salmon Historic Site	-	-	-	-	-	VI
Various	National scenic trail	Continental Divide Trail	-	-	800	-	-	IV

Source: Upper Colorado Region Comprehensive Framework Study, Appendix XII, Recreation, Adden. E-1

Table VIII-4.--Potential Recreation Resources, San Juan River Basin, Utah

County	Type Area	Area - Name	Agency		Acreage			Bureau of Outdoor Recreation Class
			Present ownership	Present administration	Undeveloped land	Developed land	Water	
San Juan	Historic area	Hatch's Trading Post	Tribal	Ute Mountain	-	40	-	VI
San Juan	Recreation area	Comb Wash	Federal	BLM	160	-	-	VI
San Juan	Recreationcomplex	Grand Gulch	Federal	BLM	19,600	-	-	VI
San Juan	Geological	Lower Coal Bed	-	-	-	-	-	VI
San Juan	Scenic area	Mule Canyon	Federal	BLM	160	-	-	IV
San Juan	Scenic area	Squaw Point	Federal	BLM	160	-	-	IV
San Juan	Scenic area	Upper Coal Bed	Federal	BLM	60	-	-	IV
San Juan	Historic area	Blanding Cliff Dwellings	-	-	75	-	-	VI
San Juan	Historic area	Blanding Archeological Site	-	-	15	-	-	VI
San Juan	Recreation area	McElmo Canyon	Federal	Navajo-Shiprock	2,000	-	1,728	III
San Juan	Recreation area	San Juan River - 54 miles	Tribal	Navajo-Shiprock	34,460	100	2,000	III
San Juan	State park	Four Corners Tribal Park	-	-	250	-	-	II
San Juan	State park	Grand Gulch - Comb Wash - Arch Canyon - Hammond Canyon	-	-	258,560	-	-	IV
San Juan	Local park	San Juan River Overlook	-	-	1,280	-	-	III
San Juan	Roadless area	Windgate Mesa Roadless Area	Federal	BLM	21,900	-	-	IV
San Juan	Recreation area	Green Water Spring	Federal	BLM	50	-	-	IV
San Juan	Archeological Sites	Numerous Archeological Sites	Federal	BLM	-	-	-	VI
San Juan	Roadless area	Grand Gulch	Federal	BLM	34,000	-	-	V

Source: Upper Colorado Region Comprehensive Framework Study, Appendix XII, Recreation, Adden. E-1

IRRIGATION SYSTEMS

Many of the irrigation systems in the basin have a potential for more efficient operation. Some of the possibilities for improving efficiencies consist of consolidation of ditch and canal systems, improved methods of water application, land leveling, ditch lining, erosion control measures and drainage. An estimated 17 percent of the presently irrigated cropland needs improved irrigation systems. All of the additional land to be irrigated from the Bureau of Reclamation projects will need irrigation systems for adequate delivery of water to the land.

FARM DRAINAGE

Farm drainage as a practice has had but limited acceptance to date. The irrigation farmers of the area have been slow in accepting the *salinity hazard* principles as stated in previous sections of this report. The leaching requirement, plus the requirement that ground water should not be allowed to more or less permanently build up in the crop root zone, should determine the intensity of drainage.

There should be a gradual expansion of drainage using the above criteria as a guide until the practice is accepted. Eventually, it can be expected that about one-third of the irrigated acreage will have drains installed. Presently the yields on these acreages, one-third of the total irrigated, are estimated to average only 50 percent of that from comparable lands which do not have salinity or drainage problems. In other words, one-third of the presently irrigated acreage produces one-fifth of the total production. With good drainage practices, a composite acre in the basin should have an increased production of 20 percent. Individual systems, or group action projects where conditions such as access, property lines, or outlet facilities are factors, are generally satisfactory.

The anticipated expansion of irrigated acreage will also increase the amount of drainage, as well as other irrigation water management practices, needed in the basin. Drainage for salinity control in the new irrigation projects will have the same development potential as that needed in the older projects.

CHANNEL IMPROVEMENTS AND LEVEES

Potential for installation of channel improvements and levees is limited to only a few localized areas. The frequency of flooding and extent of flood damages is low for the basin and feasibility of installing these types of improvements is questionable. There are, however, areas where emergency flood control works may be needed

because of urban encroachment. These urban areas would include Aztec, Shiprock and Farmington, New Mexico and Durango, Colorado.

FLOOD PLAIN MANAGEMENT

Nonstructural flood plain management techniques are important elements in reducing flood damages. Because of the present sparse population and lack of extensive developments in the flood plains of the basin, there is a good opportunity and potential for implementation of nonstructural flood damage reduction measures. Potential measures consist of zoning, subdivision regulations, building codes, flood-proofing, evacuation, open space developments, warning signs, tax adjustments, reconstruction of bridges and culverts and flood insurance.

FOREST LAND DEVELOPMENT POTENTIAL

Potential Development for Timber Production

The projected demand for timber products may be met if utilization of available wood is improved and management to achieve the full potential of growth is implemented. However, it is unlikely that full potential can be achieved since federally-owned forest lands are managed to produce a mix of goods and services. Full production of timber could only be achieved by precluding other resource uses such as wildlife, grazing, recreation, wilderness, and a variety of environmental benefits.

The supply of timber could be roughly doubled if all current losses due to insects and diseases were eliminated. Because of treatment costs, lack of access, and adverse environmental effects, it is realistic to expect that only half of these losses could be stopped. Timber from land clearing, thinning could be utilized more efficiently and wood processors could improve utilization in sawmilling and other operations. All of these measures could provide about a 70 percent increase in wood supplies available for use. It is also estimated that intensified forest management could improve the growth rate from about 28 cu ft/acre to about 100 cu ft/acre. 1/ However, the cautions presented earlier must be kept in mind in any proposal for intensified timber management.

Potential Development for Forest Land Grazing

In the future there will be increased demand on forested range to increase meat production. The capacity for grazing may be increased by 25 to 50 percent if developments such as water facilities,

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1/ *Upper Colorado Region Comprehensive Framework Study, Appendix VI, Land Resources and Use, Part III.*

fencing, and range vegetation manipulation are implemented. More intensive management of livestock and better control will be needed to make the additional developments fully productive. Careful attention to costs, other alternatives, and possible conflict with other resource uses must precede installation of improvements.

Potential Development for Outdoor Recreation

The Outdoor Recreation Resources Review Commission (ORRRC) completed a national survey of recreation potentials in the early 1960's. In addition, the major forest landowners and management agencies have accurate and recent estimates of the potential for outdoor recreation. There is sufficient suitable area in the basin to satisfy projected demands. This does not imply that the areas will be developed, but they do exist and the potential capacity is sufficient.

Potential development includes improvement and expansion of existing sites, including picnic and camping areas; boat launching sites and marinas; scenic roads; recreation trails; and winter sports areas. In addition, there are thousands of acres of roadless and undeveloped areas in all ownerships which are suitable for wilderness-type use.

Potential Development for Forest Wildlife and Fisheries

Most of the commercial forest land is classed as summer range. This habitat can be manipulated and managed to provide more wildlife. However, the treatments would have little permanent effect on wildlife populations since it is lower elevation winter range which is critical. There may be a potential to provide additional wildlife, particularly deer and elk, through treatment in noncommercial forest areas, but primarily the need is for preservation and protection of winter range.

Most of the additional fishing needs are satisfied by streams and by constructed reservoirs. Some streams can be improved, restored, or enhanced to supplement reservoirs. An excellent example of this is provided on the Mancos River. Many miles of stream fishery could be provided by deepening holes, installing overfalls, weirs, and baffles.

FISH AND WILDLIFE MANAGEMENT

The greatest potential for meeting needs and solving problems related to fish and wildlife are nonstructural. Political action resulting in regulations and authority to restrict or restructure land development proposals on the basis of damage to wildlife resources would be very helpful. Permanent zoning of key land areas for agricultural and forestry uses would assure preservation of habitat and reduce ongoing losses to subdivisions and other intensive uses. A comprehensive

land use plan in which fish and wildlife needs are recognized and provided for is potentially the most effective tool available. Land use planning should be accompanied by water planning. The potential for fish habitat use and preservation could be achieved through legal recognition of fisheries and aesthetics as beneficial uses of water.

Structural and developmental actions having good potential for meeting needs include the following:

1. Acquisition of land for wildlife uses. Winter ranges for big game and of waterfowl area are the two types of land which would provide the largest benefit. Accelerated funding by the states would be very helpful.

2. Road development to improve public access disperse use, to allow better habitat use by the animals.

3. Habitat improvement and management through control of undesirable plants and their replacement with preferable ones.

4. Fencing to protect key ranges and to control conflicts with other uses.

5. Increased use of restocking or introduction of wildlife species.

6. Inclusions of permanent fishing pools in all new improvements.

7. Reduction or elimination of grazing on the Cluska-Lukachukai-Carrizo Mountain rea of the Navajo Indian reservation.

8. Importing additional exotic species, especially game birds to fill empty ecological inches.

Potential Development for Water Management and Water Quality

Structural development and other project means are the primary ways to provide water management needs. There may be potential for increasing water yield through snowpack management in alpine and forest areas. However, these treatments are mainly valuable for prolonging the release of water and providing a more uniform rate of runoff. Research at the Forest Service Rocky Mountain Forest and Range Experiment Station has been promising. There have not been enough field applications to justify extension of the research to all areas. In addition, this basin has legal constraints on this type of development since much of the high elevation forest area is in a classified primitive area now undergoing study for reclassification to wilderness area. There are numerous roadless areas also being studied for potential inclusion into the National Wilderness Preservation System.

Snowpack management and vegetative manipulation on these areas is also prohibited until final determination on their use is made.

All-weather roads are essential to natural resource management SCS PHOTO

Potential Development for Timber Production

The projected volume demand for timber products could be met under two conditions: (1) the utilization of available wood must be improved and, (2) forest management practices leading to use of the full site potential for growth must be implemented. It is unlikely that 100 percent of the demand will be met. This is primarily because federal lands produce such a large proportion of the timber and these lands cannot be fully devoted to wood production. Full potential for timber could only be achieved by modifying or eliminating other resource uses such as wildlife, grazing, recreation, wilderness and a variety of environmental benefits.

Potentially, the supply of timber volume could be roughly doubled by elimination of all current losses to insect and diseases. It is reasonable to expect that about half of these losses could actually be realized. High treatment costs, lack of access, and adverse environmental effects would preclude total elimination of forest pests.

IX. OPPORTUNITIES FOR DEVELOPMENT AND IMPACT OF PROGRAMS

USDA DEVELOPMENT

Potential Projects

The potential USDA projects which could possibly be undertaken under the Public Law 566 Program or under the Resource Conservation and Development Program are tabulated and summarized in this section. These projects are generally single-purpose agricultural water management projects. The five projects with proposed storage facilities would include recreation as part of the reservoir use.

As pointed out in the previous chapters, livestock production is the most important agricultural industry in the Basin. Livestock production depends on the hay, pasture, corn silage and small grain grown on irrigated land to supplement the range forage. With the high demand for red meat both in the United States and abroad, the production of livestock will become more economically attractive. Livestock industry output will assist the economies of both the region and the nation.

The Soil Conservation Service in Colorado conducted watershed investigations on 12 feasible agricultural water management projects and one flood control project offering protection to an irrigation canal that transported water for 2,000 acres. These projects offer benefits in water savings, increased production and improved water quality for downstream users on 83,300 acres.

The Utah Department of Natural Resources submitted four potential agricultural water management projects benefitting 12,600 acres. One project is a proposed recreation reservoir near Monticello, Utah.

Two Watershed Investigations Reports submitted by the Soil Conservation Service in New Mexico are flood control projects offering solutions to flood problems in Aztec, New Mexico and agricultural land near Bloomfield, New Mexico.

Table IX-1 and the following narrative presents data on the potential projects which should be initiated within the early action period. The map following page IX-13 shows the location of USDA and other potential projects.

PINE RIVER-BAYFIELD DITCH

The Pine River-Bayfield Ditch is a potential flood control project located in LaPlata County near Bayfield, Colorado.

Table IX-1.--Potential USDA Projects in Colorado,
New Mexico and Utah

Project	County	Purpose 1/	Irrigation Acres Served (1000)	Water Source	Installation Cost	Average Annual Benefits ($1000)	Average Annual Cost ($1000)	Benefit Cost Ratio	Reservoir Capacity (Ac. Ft.)
COLORADO									
Pine River-Bayfield Dtch	LaPlata	F	2.0	Pine River	28.3	8.6	5.8	1.5:1	None
Spring Creek Extension	LaPlata	AWM	4.8	Pine River	55.4	14.7	4.1	3.6:1	None
Morrison Consolidated	LaPlata	AWM	6.7	Pine River	135.2	17.0	9.4	1.8:1	None
King Consolidated	LaPlata	AWM	7.0	Pine River	77.2	7.8	5.7	1.4:1	None
Thompson-Epperson Ditch	LaPlata	AWM	4.8	Pine River	22.1	10.3	1.9	5.6:1	None
Animas & Hermosa Ditches	LaPlata	AWM	2.8	Animas River	64.8	13.5	4.8	2.8:1	None
Animas Valley Ditch	LaPlata	AWM	2.7	Animas River	30.7	7.5	2.8	2.7:1	None
Echo Ditch Company	Archuleta	AWM & R	2.0	Rito Blanco	501.9	59.4	35.1	1.7:1	2300
Park Ditch	Archuleta	AWM	1.8	San Juan River	168.4	19.1	10.8	1.8:1	None
Fourmile & Mesa Ditches	Archuleta	AWM & R	1.0	Fourmile	511.6	37.5	32.7	1.2:1	2200
Summit	Montezuma	AWM & R	5.0	Lost Canyon Cr.	765.9	116.4	44.6	2.6:1	1475
Beaver Cr. Irrig. Resv.	Montezuma	AWM & R	40.0	Dolores Drng.	1540.7	123.4	112.8	1.1:1	9800
Mancos Valley	Montezuma	AWM	2.7	Mancos River	189.3	32.3	16.6	1.9:1	None
NEW MEXICO									
Aztec Watershed	San Juan	F	---	---	250.6	20.2	13.2	1.5:1	
Hammond Consv. Dist W/S	San Juan	F	4.5	San Juan River	1946.8	113.2	141.4	0.8:1	
UTAH									
Blanding	San Juan	AWM & R	2.0	Recapture and Cottonwood Cr.	4669.0	793.4	304.1	2.6:1	24,500
LaVega Reservoir	San Juan	R	80 S.A.		120.0	8.1	7.6	1.1:1	1,600
West Bluff	San Juan	AWM	1.7	San Juan River	500.0	359.0	37.0	9.7:1	None
Blanding Irrig. Co.	San Juan	AWM	4.0		110.4	10.0	7.0	1.4:1	None
Bluff Bench	San Juan	AWM	4.9	San Juan River	3000.0	1000.0	222.2	4.5:1	None

1/ F = Flood Control
AWM = Agricultural Water Management
R = Recreation

The primary problem is disruption of irrigation water delivery caused by floodwaters breaking canal or dumping sediment in the canal. Canal damage is from 10 side drainages that the canal crosses as it transports irrigation water from the Los Pinos (Pine) River to 2,000 acres of irrigated land. The present cropping pattern on the irrigated land is 85 percent hay and pasture; 15 percent small grain and corn silage.

The proposed structural measures include structures that would allow the flood waters to bypass the canal safely and continue downstream in the natural drainageway.

Pine River-Bayfield Ditch sluice structure needs to be replaced SCS PHOTO

SPRING CREEK EXTENSION

The Spring Creek Extension Ditch is located in LaPlata County near Ignacio, Colorado. It transports Pine River water to 33 water users for about 4,800 acres of irrigated land. The irrigated land produces feed and forage for livestock and the cropping pattern is 80 percent hay and pasture and 20 percent small grain and corn silage.

The primary problem is a low efficiency irrigation delivery system with inadequate ditch capacity during peak consumptive use periods, and poor condition water control structures. Structural measures proposed for system rehabilitation include several water control structures along with five miles of canal resectioning.

Agricultural water management benefits will accrue from water savings, increased production and reduced operation and maintenance costs.

MORRISON CONSOLIDATED

The Morrison Consolidated Ditch Company is located in La Plata County. Irrigation water is diverted from the Pine River and transported in the Morrison Ditch to 62 water users for irrigating about 6,700 acres. The irrigated area has a cropping pattern of 84 percent hay and pasture and 16 percent small grain and corn silage. Feed produced is for livestock consumption.

The primary problem is that the irrigation delivery system is inefficient in its water delivery due to structures in poor condition. Additionally, there is an inability to properly dispose of excess runoff water and sediment. The proposed structural measures for irrigation system rehabilitation include various water control structures, siphons and measuring flumes.

Agricultural water management benefits will accrue from water savings, increased production and reduced operation and maintenance costs.

KING CONSOLIDATED

The King Consolidated Ditch is located in La Plata County. The King Ditch diverts water from the Pine River and transports the water to 80 water users for irrigating about 7,000 acres. The irrigated area has a cropping pattern of 65 percent hay and pasture and 35 percent small grain and corn silage. The feed and grain produced is for supporting the livestock industry.

The primary problem is similar to the above projects with an inefficient irrigation delivery system and inability to properly dispose of excess runoff water and sediment. The proposed structural measures for irrigation system rehabilitation include concrete lining, water control structures, 12 miles of ditch resectioning and measuring flumes.

Agricultural water management benefits will accrue from water savings, increased production and reduced operation and maintenance costs.

THOMPSON-EPPERSON DITCH

The Thompson-Epperson Ditch is located in La Plata County west of Bayfield, Colorado. The ditch diverts water from the Pine River and transports the water to about 4,800 acres of irrigated land, with a cropping pattern of 70 percent hay and pasture and 30 percent small grain and corn silage. The feed and grain are utilized by livestock grown locally.

The primary problem is an inadequate irrigation system resulting in low efficiency of water use.

The proposed structural measures for improving the efficiency of the irrigation system include ditch lining, water control structures, ditch realignment and measuring flumes.

Agricultural water management benefits will accrue from water savings, increased production, and reduced operation and maintenance costs.

ANIMAS AND HERMOSA DITCHES

The Animas and Hermosa Ditches are located in La Plata County. They deliver irrigation water to an estimated 205 farms with about 2,800 acres of irrigated land. The present cropping pattern is 67 percent pasture, 18 percent hay and 15 percent orchard and truck gardens. The pasture and hay is used for livestock production locally.

The primary problem for both ditches is the inefficient irrigation delivery system.

The proposed structural measures for rehabilitating the two systems include ditch lining, resectioning six miles of ditch, water control structures, and two diversion structures.

Agricultural water management benefits will accrue from water savings, increased production, and reduced operation and maintenance costs.

ANIMAS VALLEY DITCH

The East Animas Ditch is located in La Plata County, north of Durango, Colorado. The ditch diverts water from the Animas River and delivers the irrigation water to 56 farms with about 2,700 acres of irrigated land. The present cropping pattern is 74 percent pasture, 18.5 percent alfalfa and 7.5 percent orchard and truck gardens, with about 150 acres included of commercial orchards.

The primary problem on the system is the inefficiency of the system with seepage losses and inadequate capacity to meet peak consumptive use periods.

The proposed structural measures for improving the efficiency include 1,300 feet of canal improvement, line 1500 feet of ditch, water control structures, and road culverts.

Agricultural water management benefits will accrue from water savings, increased production, and reduced operation and maintenance costs.

ECHO DITCH COMPANY

The Echo Ditch is located in Archuleta County and transports water from Rio Blanco Creek to seven ranches, irrigating about 2,600 acres of hay and pasture for livestock production.

The primary problem is the lack of late season irrigation water along with an inefficient irrigation delivery system.

The proposed structural measures include an 1800 acre-foot storage reservoir, with recreational facilities, ditch resectioning, water control structures, and measuring flumes.

Agricultural water management benefits will accrue from water savings, increased production, and reduced operation and maintenance costs.

PARK DITCH

The Park Ditch is located in Archuleta County near Pagosa Springs, Colorado. The ditch transports water from the San Juan River to about 1,600 acres of irrigated land used for pasture and hay production.

The primary problem is the maintenance problem on a steep slope where the ditch is cut into the side hill. The hill is underlain by shale of the Mancos formation. Water seepage from the ditch causes slides and sections of the ditch can slide downhill. Weathered shale above the ditch can slide and fill ditch with shale in the same area. Two diversion structures need replacement due to inefficient condition.

The proposed structural measures include 2,400 feet of 54-inch diameter pipeline with appurtenances, and two diversion structures.

Agricultural water management benefits will accrue from water savings and reduced operation and maintenance costs.

FOURMILE AND MESA DITCHES

The Fourmile and Mesa Ditches are located in Archuleta County north of Pagosa Springs, Colorado. The ditches divert water from Fourmile Creek and transport irrigation water to about 2,000 acres of irrigated land used for hay and pasture to sustain the livestock production.

The primary problems are the need for water during latter part of the growing season and canals with a greater capacity.

The proposed structural measures include a 2,200 acre-foot irrigation storage reservoir, with recreation facilities, two miles of canal enlargement, one mile of diversion ditch and water control structures.

Agricultural water management benefits will accrue from additional water storage, and a more efficient delivery system.

SUMMIT RESERVOIR & IRRIGATION COMPANY

The Summit Reservoir and Irrigation Company operates three existing reservoirs with a combined capacity of 8,445 acre-feet located about 26 miles northeast of Cortez, Colorado. The reservoirs are filled from Lost Canyon Creek and Turkey Creek, tributaries to the Dolores River. The three reservoirs serve about 5,000 acres of irrigated land. The present land use is 70 percent pasture and hayland, and 30 percent small grain.

The primary problem is the shortage of irrigation water storage and deteriorated and inefficient canals.

The proposed structural measures include a 1475 acre-foot storage reservoir with recreation facilities, ditch resectioning, and water control structures.

Agricultural water management benefits will accrue from water savings, additional water supply, increased production, and reduced operation and maintenance costs.

BEAVER CREEK IRRIGATION RESERVOIR

The Montezuma Valley Irrigation Company serves 86,240 acres of which about 35,620 acres are presently being irrigated. The irrigated area is located in Montezuma County near Cortez, Colorado and is used primarily for pasture and hay production, with about 3 percent in small grain and fruit.

The primary problem is the lack of sufficient late season water resulting in lower crop production.

The proposed structural measures include a 9,800 acre-foot irrigation storage reservoir, with recreation facilities, and 11,000 feet of ditch.

The Bureau of Reclamation's proposed McPhee Reservoir under the Dolores project would insure a full water supply to the same acreage, and the Beaver Creek Reservoir would not be necessary, if the McPhee Reservoir becomes a reality.

Agricultural water management benefits would accrue from the increased production due to the additional water.

MANCOS VALLEY

The Mancos Valley, a potential agricultural water management project, is located in Montezuma County south of Mancos, Colorado. The Weber Ditch No. 1 and the Root-Ratliffe Ditch divert water from the Mancos River and transport the water to about 2,700 acres of irrigated hay and pasture land to support livestock production.

The primary problem is an inefficient irrigation delivery system resulting in a high loss of water.

The proposed structural measures include 12 miles of ditch realignment, 16 miles of ditch resectioning, 800 feet of diversion ditch, 45 water control structures, and 30 measuring flumes.

Agricultural water management benefits will accrue from water savings, increased production, and reduced operation and maintenance costs.

Mancos Valley - Water control structures need to be replaced SCS PHOTO

The following two potential flood control projects were summarized from Watershed Investigation Reports submitted by the Soil Conservation Service in New Mexico.

AZTEC WATERSHED

The Aztec watershed, a potential Public Law 566 project, is located in San Juan County, New Mexico. The town of Aztec is near the center of the watershed. The watershed contains 144,640 acres of which 37 percent are in private ownership, 55 percent are federal, and 8 percent state owned.

The primary problem is caused by flooding from three arroyos that direct their sediment-laden floodwaters into the town of Aztec damaging homes, businesses, and public property.

The proposed structural measures include three Class C floodwater retarding structures with appurtenant works.

HAMMOND CONSERVANCY DISTRICT WATERSHED

The watershed contains 112,000 acres of which 12.6 percent are in private ownership; 83.3 percent federal and 4.1 percent state; 101,900 acres are in rangeland; 4,500 acres irrigated cropland, and 5,600 acres in farmsteads, roads, irrigation canals and waste-land. The watershed is located in central San Juan County, about one mile south of Bloomfield, New Mexico. The watershed is bound on the north by the San Juan River.

Hammond Watershed - Floodwater structures are needed to protect irrigated land

SCS PHOTO

The primary watershed needs are (1) intensive grazing management, brush control and reseeding adapted areas to grass, (2) a system of floodwater retarding structures on the larger arroyos and trap sediments that normally ravage irrigated fields, and (3) irrigation practices that will provide uniform field distribution of water.

The proposed structural measures are (1) 8 floodwater retarding structures, (2) one floodwater diversion, (3) bank protection on two canyons.

The following potential project summaries were submitted by the Utah Department of Natural Resources. Tables IX-2 and IX-3 present project costs and benefits in a tabular form.

Approximately 12,600 acres of irrigated land in Utah would be benefitted by four potential projects. One potential recreation project is located near Monticello, Utah.

BLANDING PROJECT

The Blanding project consists of the Recapture and Cottonwood units in the vicinity of Blanding, San Juan County, Utah. Both units will provide irrigation water to the area.

The Recapture unit consists of a 7,500 acre-foot reservoir on Recapture Creek, a pump plant and pipeline, and canal lining. The reservoir would provide supplemental water to 670 acres of presently irrigated land, and an additional 330 acres under cultivation but not normally irrigated. Under the proposed development, the farmers would continue to grow forage and small grain crops in support of the local livestock industry.

The Cottonwood unit consists of a 17,000 acre-foot reservoir with recreational facilities on Cottonwood Creek, a holding pond, and a pumping pland and pipeline from the reservoir to the holding pond. The reservoir was designed to provide for a full water supply of 3,000 acre-feet for new irrigation of 1,000 acres of horticultural crops.

A detailed agricultural feasibility report and an environmental impact statement for the Blanding Project have been prepared by consultants. The project has been submitted to the Bureau of Reclamation for funding under the Small Reclamation Project program.

LaVEGA RESERVOIR

The LaVega Reservoir located approximately three miles east of Monticello would be developed for recreation use. It would have a

storage capacity of 1,600 acre-feet and provide 80 surface acres. Most of the projected use would be local as nearby Lake Powell can provide ample boating and fishing opportunities for nonresident recreationists. The site is projected to provide nearly 11,000 visitor-days use annually.

WEST BLUFF PROJECT

The West Bluff Project includes the Bluff Project Area and will service irrigated and irrigable lands along the San Juan River near Bluff, San Juan County, Utah. This project could supply irrigation water to 1,672 acres by gravity or minimal pump lift, depending on the location of the diversion structure. A detailed agricultural report has been prepared under contract to the Division of Water Resources and the San Juan Water Conservancy District.

The Bluff area has at present 260 acres under cultivation, principally alfalfa, all the result of private development. With the project, higher yields are expected and the acreage is projected to increase 539 acres. The land is privately-owned and alfalfa will continue to be the major crop.

The West Bluff area is well suited to horticultural crops. Projections are that about 640 acres of new lands would be planted in grapes, and the remainder in alfalfa and other forage crops. A marketing study for the grapes was included in the agricultural report.

BLANDING IRRIGATION COMPANY

The Blanding Irrigation Company desires to improve their delivery system by installing two diversion structures and 700 feet of welded steel pipe capable of carrying 50 c.f.s. varying in size from 18 to 24 inches. These facilities will permit better utilization of irrigation water.

BLUFF BENCH PROJECT

The Bluff Bench project consists of pumping water from the San Juan River for irrigation of approximately 4,900 acres of presently uncultivated land. This land is located 250 to 500 feet above the river north of the town of Bluff, Utah and is presently 90 percent federally owned (administered by Bureau of Land Management). The project would consist of pumps, a desilting pond, and a pipeline and distribution system to the project lands.

The Bureau of Reclamation studied this project in the San Juan investigation, but it appeared uneconomical if analyzed under a predominantly alfalfa cropping pattern. An agricultural economist has prepared a report under contract to the Utah Division of Water Resources and the San Juan Water Conservancy District, and concluded that horticultural crops (fruit and grapes) can be grown in the project area and marketed successfully.

Land Treatment Opportunities on Dry Cropland and Rangeland

Conservation land treatment is a continuing need on agricultural lands, and may require a combination of improvement measures including management and structures. The following measures and practices are typical of the requirements of this area.

DRY FARM CROPLAND

1. Residue and annual cover - Crop residue management, annual cover crops, or other annual recurring measures used locally when needed to meet the conservation problems.

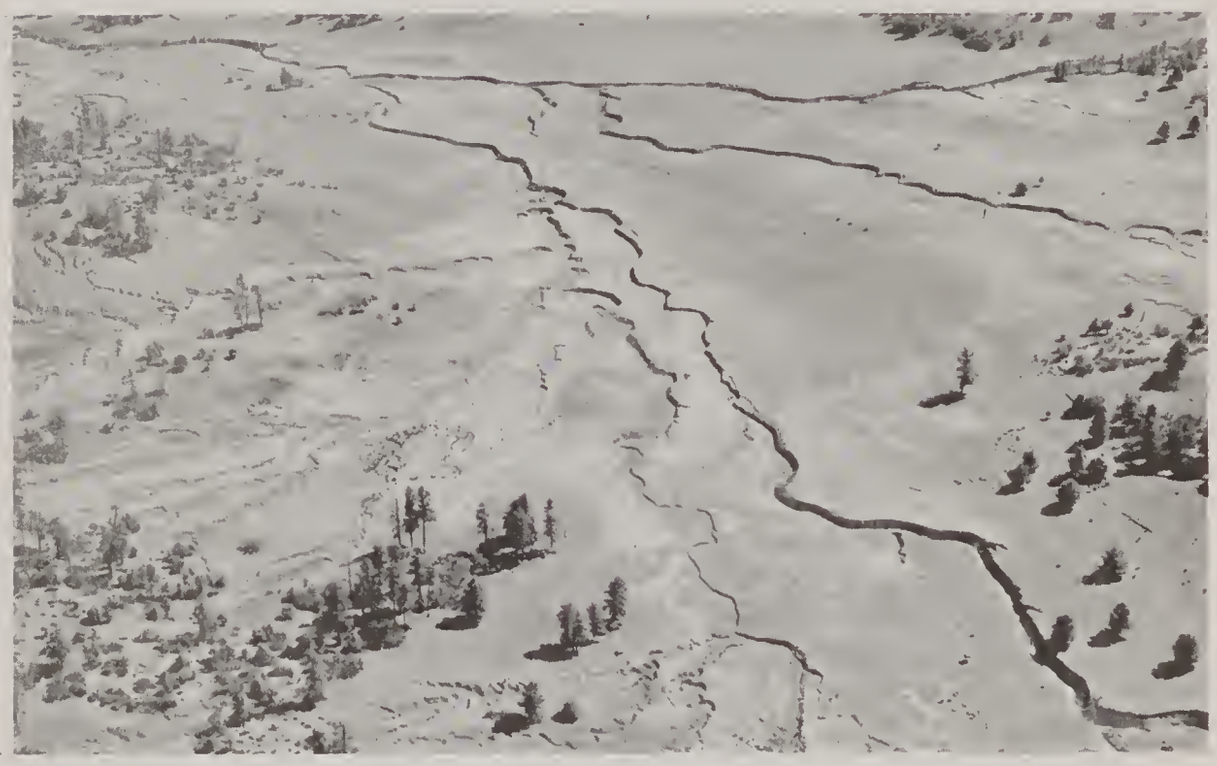
2. Stripping and diversions - This includes strip cropping and diversions that are needed to treat and protect the land. In addition, measures such as sod waterways and contour stripping may be used to supplement these practices.

3. Permanent cover - This practice is for lands that are unsuited for row or grain crops, and a land use change to a permanent cover of grass or trees is needed.

RANGELAND

1. Protection only - Protection of plant cover from overgrazing. Livestock managwment and distribution is needed on overgrazed land to enable rangeland to recover and reseed naturally.

2. Brush control and improvement - Chemical or mechanical measures are needed to eradicate or control the encroachment of undesirable woody, poisonous, and noxious plants that have destroyed or threaten the grass cover.

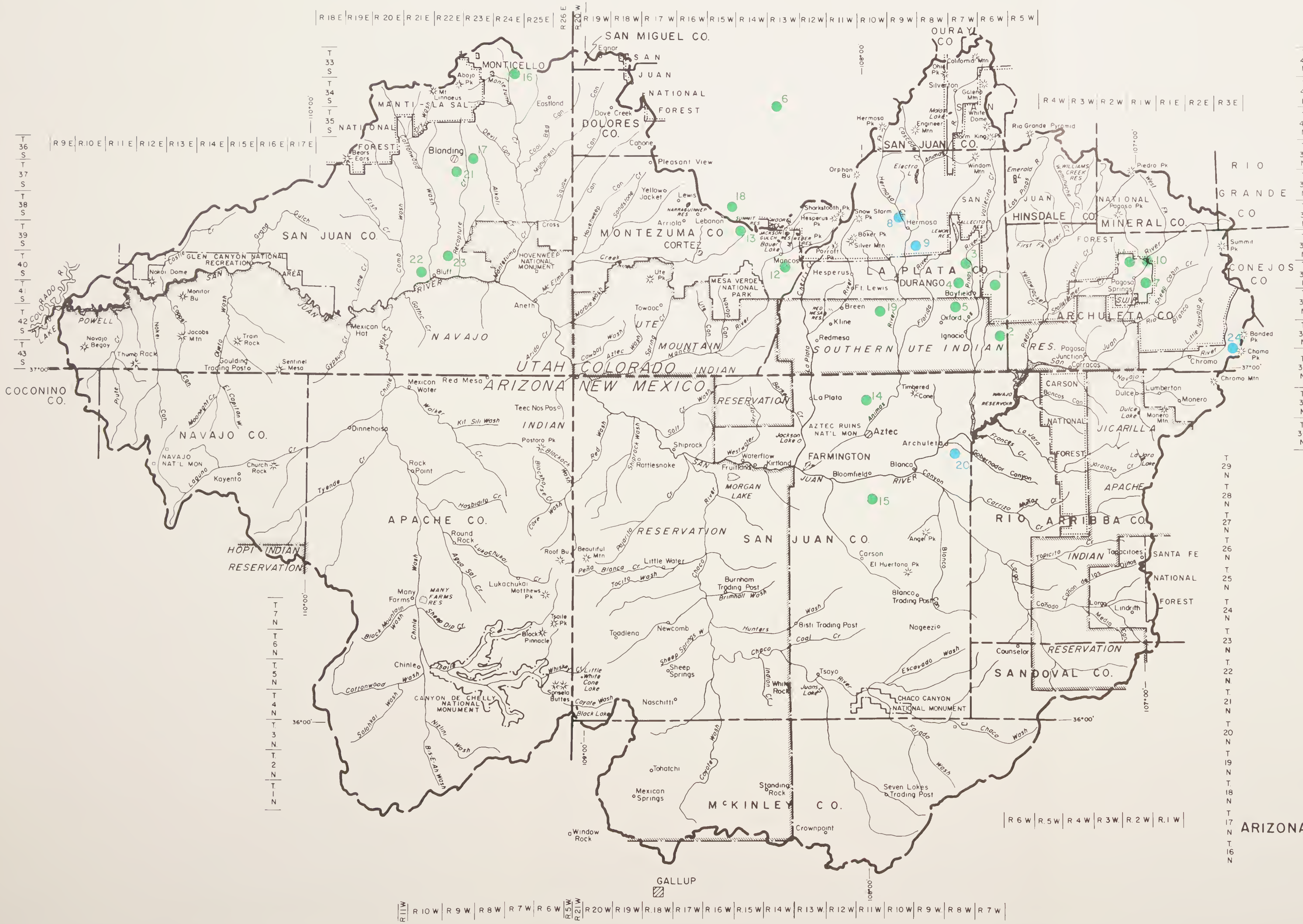


Reestablishment of vegetative cover is needed to stabilize critical erosion areas

SCS PHOTO

3. Reestablishment of vegetative cover - This is a more intensive treatment. The pasture or range needs a complete reestablishment (without brush control) of vegetative cover. During the period of reestablishment these lands are protected from livestock grazing that might cause damage.

4. Reestablishment with brush control - Brush control measures are necessary in the reestablishment of a desirable vegetative cover.



LOCATION MAP

LEGEND

- Potential Project
- Project Under Construction

USDA

1 Pine River - Bayfield Ditch
2 Spring Creek Extension
3 Thompson - Epperson Ditch
4 King Consolidated
5 Morrison Consolidated
6 Beaver Creek Irrigation Reservoir (Alt. to 18)
7 Echo Ditch Company
8 Animas Consolidated & Hermosa Ditch
9 Animas Valley Ditch
10 Park Ditch
11 Four Mile & Mesa Ditches
12 Mancos Valley
13 Summit
14 Aztec
15 Hammond
16 La Vega Reservoir
17 Blanding Irrigation Company

USBR

18 Dolores
19 Animas La Plata
20 Navajo Irrigation
21 Blanding
22 West Bluff
23 Bluff Bench
24 San Juan - Choma

PROJECT LOCATION MAP
SAN JUAN RIVER BASIN
ARIZONA, COLORADO, NEW MEXICO, AND UTAH

MARCH 1974

10 0 10 20 MILES

SCALE 1:1,150,000

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1974

M7-N-23214

The following table shows conservation treatment needs by state on state, local government, Indian and private lands.

Table IX-2.--Treatment Opportunities on Dry Farm Cropland and Rangeland

Land Use	Description of Treatment Needed	Treatment Needed (1000 Ac) Arizona	Colorado	New Mexico	Utah
Dry Farm Cropland	Residue and annual Cover	0	62.7	2.7	51.0
	Stripping & Diversions	0	74.9	1.8	28.7
	Change to Permanent Cover	0	18.5	0.8	5.8
Rangeland	Protection only	1511.6	238.3	1355.4	802.5
	Brush control and improvement	222.4	65.7	490.0	9.0
	Reestablishment of vegetative cover	245.7	23.2	56.7	60.0
	Reestablishment with brush control	28.3	25.4	20.6	24.0

Source: County Conservation Needs Inventory (1969). Data adjusted to the San Juan River Basin boundary.

Structural measures applying to rangelands include gully plugs, erosion control dams and stockwater ponds to reduce erosion and permit better utilization of range forage. Structure location or modification could permit them to serve more than one purpose.

Treatment Opportunities on Irrigated Land

Tables IX-3 and IX-4 tabulate treatment opportunities for irrigated land by state regarding water storage capacity, structural, and drainage needs as well as, management opportunities for increasing the overall efficiency of irrigation water use.

Table IX-3.--Off-farm treatment opportunities

State	Reservoir Storage (1000 ac.ft.)	Lining and Piping (1000 ft.)	Water Control Structures (No.)	Main Drains (1000 ft.)
Arizona	6	2	50	--
Colorado	200 1/	704	400	230
New Mexico	--	350	20	--
Utah	26.1	15	40	--

Source: Soil Conservation Service, Water Conservation & Salvage Study.

1/ Includes 120,800 acre-feet in proposed McPhee Reservoir.

Table IX-4.--On-farm treatment opportunities

State	On-farm systems				Management		
	Ditch Piping and Lining (1000 ft.)	Water Control Structures (No.)	Drainage (1000 ac.)	Irrigation Method Change (1000 ac.)	Timing & Scheduling (1000 ac.)	Proper Application (1000 ac.)	Better Technology (1000 ac.)
Arizona	200	800	0.8	2.0	10.0	10.0	10.0
Colorado	950	9600	16.2	38.2	154.9	154.9	118.0
New Mexico	484	6000	7.2	16.5	28.0	28.0	28.0
Utah	150	600	0.7	1.5	6.0	6.0	6.0

Source: Soil Conservation Service, Water Conservation & Salvage Study.

BUREAU OF RECLAMATION

The Dolores Project would develop flows of the Dolores River for irrigation, municipal and industrial use and recreation. The principal storage feature would be the proposed McPhee Reservoir with a capacity of about 372,000 acre-feet. Canals and laterals would be required to serve lands in the Dove Creek and Towaoc areas.

Present advance planning studies involve a reformulation of the project and a review of the salinity problem. The project is being reformulated to meet the needs for the following multipurpose objectives:

1. Municipal, industrial and rural water to serve the communities of Cortez, Towaoc, Dove Creek, Dolores, and the outlying rural areas.

2. Indian resource development of the Ute Mountain Ute Indian Reservation.

3. Supplemental irrigation of presently irrigated lands within the Montezuma Valley Irrigation System.

4. Provide irrigation water supplies for presently formed dry lands between Cortez and Dove Creek.

5. Increase fish and wildlife habitat and expand recreational opportunities.

The Animas-La Plata Project would develop flows of the Animas and La Plata River systems for irrigation, municipal and industrial use, recreation, and fish and wildlife conservation.

Present advance planning activities include a comprehensive reevaluation of the plan as formulated in the authorizing report. A reassessment of the area's needs is also being made. Current plan formulation studies include a scaled down development of both irrigation and municipal and industrial water supplies. Water requirements for the communities of Durango, Aztec, and Farmington are being made.

Major mineral discoveries made at the proposed Howardsville Dam and Reservoir are significant as reported by the Bureau of Mines. Accordingly, alternate sites are being considered. Alternative plans of sites between Silverton and Durango, are not being considered because of the necessity of relocating a scenic railroad that has been designated a historical monument.

The project would be of particular value to the Southern Ute and Ute Mountain Ute Indian tribes through the irrigation of Indian land, and by making water available for municipal and industrial development of mineral resources, principally coal.

Hay Gulch - irrigated land would receive supplemental water from the Animas-La Plata Project SCS PHOTO

The Navajo Irrigation Project is under construction with the completion of the 1,696,000 acre-foot Navajo Dam and Reservoir. The irrigation water delivery system is presently under construction and plans include the irrigation of an additional 110,000 acres in New Mexico.

The lands in all three projects are in a favorable climate for the production of pasture, alfalfa, small grains, dry beans, corn silage, vegetable crops and in some areas fruit and berries such as strawberries, peaches, apricots, apples and pears.

San Juan-Chama Project is almost completed and will export an annual average of 110,000 acre-feet of water from the headwaters of the San Juan River in Colorado to the Rio Grande Basin in New Mexico for the following purposes: (1) provide irrigation water for 39,300 acres in the Cerro, Taos, Llano and Pojoaque irrigation units and 81,600 acres in the Middle Rio Grande Conservancy District, (2) for municipal, domestic and industrial uses, and (3) provide recreation and fish and wildlife benefits.

Colorado River Water Quality Improvement Program - McElmo Creek

The McElmo Canyon Salinity Control Study is a part of the Bureau of Reclamation's on-going comprehensive 10-year water quality improvement program. McElmo Creek is a tributary of the San Juan River, occupies a drainage area of 350 square miles, and the salt loading is estimated to be 115,000 tons per year. Feasibility studies initiated in fiscal year 1972 indicate that about 40,000 tons could be removed by selective withdrawal and evaporation or desalting.

BUREAU OF INDIAN AFFAIRS

The Ute Mountain Ute Indian Reservation consists of nearly 558,000 acres of trust lands of which about 87 percent is considered as usable grazing land. The present authorized grazing capacity of the trust lands is 20,624 AUM's. Livestock use during 1969 totaled 43,281 AUM's.

There are several project proposals which have been submitted to the San Juan Resource Conservation and Development Council concerning these trust lands. These proposals have as an objective the achievement of a potential grazing capacity of 64,500 AUM's on these lands by the year 2000. The major features of these proposals include: (1) installation of flood control and detention structures to control soil erosion and prevent damage to range forage, water storage structures, and other property from washing and siltation, (2) construction of diversion and water spreading structures which provide for watershed protection and increased livestock forage production, (3) reseeding, revegetation, and proper grazing on currently denuded watersheds, (4) development of adequate stock water by constructing approximately 160 stock ponds and drilling 75 wells for windmill-tank use, (5) reseeding 40,000 acres of depleted grassland, (6) clearing or spraying and reseeding 65,000 acres of brushland which consists of pinyon-juniper, big sagebrush, and greasewood, and (7) building approximately 50 miles of diversion fences for improved livestock distribution and control.

Grazeable woodland - Ute Indian Reservation

SCS PHOTO

National Forest Developments & Multiple Use Programs

There are many opportunities for accelerated development to meet projected needs and solve problems on the national forest lands.

Land treatment measures during the 1970's and 1980's are important features of the national forest program. Area treatment may consist of establishing range grasses, plant control, fertilizing, tree planting, timber stand improvement, sloping and revegetating roadbanks, fencing, range water developments, control of grazing, improvement of transportation facilities, wildlife habitat improvement, and many other activities. These measures will provide protective cover for the critical areas, increase the infiltration and percolation rates of the soil, reduce the rate of erosion, the production of sediment, and stabilize the rate of runoff. They will also contribute to satisfaction of the growing demands for forestry related goods and services.

Table IX-5 compares the early action period (next 10 to 15 years) accelerated program opportunities with the forest development needs shown on Table VI-5. These opportunities can be achieved through application of existing programs. Accomplishment will depend upon the availability of funds and manpower required.

State and Private Forest Land Programs

Existing cooperative forestry programs can be accelerated or initiated to help meet needs and solve problems on nonfederal public lands and private forest lands. These programs provide a variety of forestry projects and measures for development and protection of these forest lands. The programs are applied under the direction of the State Foresters. The state agencies, private forest owners, processors, rural community planners, developers, and the Forest Service cooperate to implement the programs. Table IX-6 shows the total need for development on private lands (from Table VI-5) and the opportunity for accelerated treatment in the early action period.

There is also an opportunity to assist local economies and meet projected timber demands through accelerated assistance to wood producers and processors. About 2,000 marketing and utilization studies could be made if this program was accelerated.

Impact of Projected Development

ECONOMIC EFFECTS

The beneficial and adverse effects of the 20 potential USDA projects are displayed in Tables IX-7, IX-8, IX-9 and IX-10. The net beneficial effects on national economic development resulting from projects to be installed is about $1,698,800. Net beneficial effects on regional development will be about $2,302,600.

Table IX-5--Comparison of national forest opportunities for accelerated treatment and development in the early action period with estimated treatment needs for public forest lands. Carson, Manti-LaSal, San Juan, and Santa Fe National Forests, San Juan River Basin, Arizona, Colorado, New Mexico and Utah.

Item	Unit	Public Land Need	Opportunity for Accelerated Treatment on National Forest
Watershed protection			
Sheet erosion control	acres	3,500,000	62,800
Gully control	miles	1,320	1,320
Fire management	acres	2,300	1.700
Flood & sediment damage control	acres	25,400	19,000
Timber production			
Thin, prune, release	acres	171,000	43,700
Tree planting and seeding	acres	85,000	60,300
Range improvement			
Grazing management	acres	2,500,000	1,900,000
Water development	each	1,160	740
Fencing	miles	1,800	400
Plant Control	acres	25,200	19,000
Revegetation	acres	3,800	2,400

Source: The Upper Colorado Region Comprehensive Framework Study, Appendices VI, VIII, and XVIII. National Forests Project Work Inventory and Field Inventories completed for this study.

Table IX-6-- Comparison of non-federal public and private forest land opportunities for accelerated treatment and development in the early-action period with estimated treatment needs. San Juan River Basin, Arizona, Colorado, New Mexico, and Utah.

Item	Unit	Development Need	Opportunity for Accelerated Treatment
Watershed protection			
Sheet erosion control (Primarily through reduction of over-grazing)	acres	1,000,000	1,000,000
Fire management	acres	700	700
Flood and sediment damage control	acres	7,600	1,100
Timber production			
Install management	acres	262,000	262,000
Thin, prune, release	acres	8,000	3,000
Tree planting and seeding	acres	18,000	7,000
Range improvement			
Grazing management	acres	4,000,000	4,000,000
Water development	each	395	75
Fencing	miles	170	35
Plant control	acres	286,000	101,000
Revegetation	acres	246,000	63,000

Source: Upper Colorado Region Comprehensive Framework Study, Appendices VI, VIII, and XVIII, field inventories, and information compiled by State Forester organizations for this study.

Flood control provided in Aztec, New Mexico will provide protection to homes, businesses, and public property. This protection will help prevent loss of life, income, and public services. An estimated $20,200 average annual benefits will be afforded residents and businesses of this area.

Installation and operation of the proposed projects will create 1,442 semi-skilled jobs for five years and 10 permanent semi-skilled jobs for operation and maintenance of structural measures. In addition, 4610 permanent semi-skilled jobs will be created in the agricultural, service, and trade industries. Agricultural employment of five man-years will be lost because of the project take area. The recreation service sector will receive 113 semi-skilled jobs.

It is expected that improved and new irrigation systems will increase pasture and hay about two tons per acre, small grain ten bushels per acre, and silage two tons per acre. The irrigation systems will provide full season irrigation for 100,400 acres.

Implementation of the proposed projects will create new demands upon the transportation, processing, and marketing industries of the project area. An increase in production of goods produced in this area will result in a greater demand for these services.

Additional benefits will result from the supplying of additional materials and services required to make possible the increased net returns which stem from the installation of the various facilities. An example would be the increased net income of a fertilizer and seed dealer from sales of additional fertilizer and/or seed to the producers of the project area.

The increased economic activity described in the two above paragraphs is estimated to be 10 percent of direct primary benefits and 10 percent of increased cost of production respectively.

RECREATIONAL OPPORTUNITIES & BENEFITS

Recreation developments at the various projects will provide 129,300 annual recreation visits. This increased tourist activity will generate added income for the service industries, such as food and gas establishments.

Recreational activities available to local residents and the general public will include picnicking, fishing, hiking, sightseeing, and nature study. Recreational benefits are estimated to be $193,000 annually.

SOCIAL AND INSTITUTIONAL

Beneficial effects on social factors of the region will include the creation of 1,442 new, low to medium jobs for five years, and 4,610 permanent semi-skilled jobs. The recreation service sector will experience an increase of 113 seasonal semi-skilled jobs. The jobs will help distribute real income of the area to the unskilled. The project take area will cause a loss of five man-years of agricultural employment.

Other social benefits for the residents of this basin will be increased income resulting from improved or new irrigation systems. The increased net income will allow the local people to improve their health care, purchase better foods and attain a higher education for their children. Increased net income will also result in more general tax revenues. As incomes in the basin increase, consumer expenditures will accelerate resulting in more taxes for local governing bodies to use for essential services, such as better roads, schools, and hospitals.

USDA PROGRAM EFFECTS

Beneficial & Adverse Effects

POTENTIAL P.L.-566 Projects

The beneficial and adverse effects of the potential PL-566 projects are displayed against the multiple objective planning accounts as described in the Water Resources Council's "Proposed Principles and Standards for Planning Water and Related Land Resources". The effects displayed for national economic development, regional development, quality of environment, and social well-being are as follows.

Table IX-7--National Economic Development

Components	Measures of Effects 2/
Beneficial Effects:	
A. The value to users of increased output of goods and services.	
(1) Irrigation	$2,396,100
(2) Flood Control	127,800
(3) Recreation	193,900
Total Beneficial Effects	$2,717,800
Adverse Effects:	
A. The value of resources required for a plan, e.g., project construction and O&M.	
Total Adverse Effects	$1,019,000
Net Beneficial Effects	$1,698,800

1/ Federal Register, 36(245), December 21, 1971

2/ Dollars in Average Annual Equivalents

Table IX - 8--Regional Development

Components	Measures of Effects 1/	
	Project Area	Rest of Nation
A. Income		
Beneficial Effects:		
a. The value of increased outputs of goods and services from a plan to the users residing in the region under consideration		
Flood Control	$ 142,000	
Irrigation	2,435,500	
Recreation	193,900	
Total Beneficial Effects	$2,771,400	
Adverse Effects:		
a. The value of resources contributed from within the region under consideration to achieve the output of a plan.		
Construction, Engineering, Project Administration, O&M Lands, easements, and rights-of-way	$ 468,800	$ 550,200
Total adverse effects	$ 468,800	$ 550,200
Net Beneficial Effects	$2,302,600	$-550,200
B. Employment		
Beneficial Effects:		
a. Increase in the number and types of jobs resulting from a plan in the region under consideration.		
Employment for project construction	1442 semi-skilled jobs for 5 years	
Employment in recreation service sector	113 permanent seasonal semi-skilled jobs	
Employment for project O&M	10 permanent semi-skilled jobs	

1/ Dollars in average annual equivalents

Table IX-8-Regional Development (contd)

Components	Measures of Effect: Project Area	Measures of Effect: Rest of Nation
Agricultural Employment	2900 permanent semi-skilled jobs	
Employment in service and trade activities induced by and stemming from project operation	1700 permanent semi-skilled jobs	
Total Beneficial Effects	1442 semi-skilled jobs for 5 years 113 permanent seasonal semi-skilled jobs 4610 permanent semi-skilled jobs	
Adverse Effects:		
a. Decrease in number and types of jobs		
1. Loss in agricultural employment of project take area	5 man-years of agricultural employment	
Total Adverse Effects	5 permanent semi-skilled jobs	
Net Beneficial Effects	1442 semi-skilled jobs for 5 years 113 permanent seasonal semi-skilled jobs 4605 permanent semi-skilled jobs	

Table IX-8-Regional Development (contd)

Components	Measures of Effect : Project Area	Rest of Nation
C. Regional Economic Base and Stability		
Beneficial Effects:----------	Project structural measures will be effective in decreasing peak flows, resulting in (1) reduced area and depth of floodwater inundation; (2) reduced erosion and sediment transportation; (3) reduced damage to highways, railroad, residential and commercial properties; and (4) reduced damage from canal breaching. Project measures will provide full season irrigation water supply for 100,400 acres in an area where agriculture is a significant part of the local economy. The resulting effects of these measures will be an improvement in the watershed environment and economy.	

Table IX-9--Social Well-being

Component	Measures of Effects
A. Real Income Distribution---------	1. Create 4718 low to medium income permanent jobs and 1442 jobs for 5 years for unskilled and semi-skilled workers.

2. Create regional income benefit distribution of $2,302,600 by income class as follows:

Income Class (Dollars)	Percentage of adjusted Gross Income in Class	Percentage Benefits in Class
Less than 3,000	13	3
3,000-10,000	56	45
More than 10,000	31	52

3. Local cost to be borne by region - total $468,800 with distribution by income class as follows:

Income Class (Dollars)	Percentage of Adjusted Gross Income in Class	Percentage Benefits in Class
Less than 3,000	13	3
3,000-10,000	56	45
More than 10,000	31	52

B.	Life, Health and Safety ----------	1. Flood control will provide protection for homes, businesses, and public property of Aztec, New Mexico.
		2. Improved irrigation systems will increase disposable income that van be used for health care, food and education.
C.	Increased Taxes----------	1. Increased net income will result in more consumer spending in Basin, thereby increasing sales taxes revenues.
D.	Recreational Activities----------	1. Create 129,300 annual recreation visits for general public.

Table IX-10.--Selected Alternative Environmental Quality Account, San Juan River Basin

AREAS OF NATURAL BEAUTY

1. Five proposed projects would replace 1,600 acres of pasture, hayland, and brushland with row crops.

2. Reduction of canal erosion would improve visual quality and improve water clarity.

3. Two proposed projects would stabilize slip bank areas and establish vegetation on previous highly erodible land.

4. Seven new multiple use reservoirs are planned for construction. The reservoirs would provide 1,000 surface acres.

5. Construction of multiple use reservoirs would provide desirable recreational facilities in the river basin.

6. The West Bluff project would change 640 acres of land use from range production to grape production.

7. All proposed projects listed in the San Juan River Basin report would create structural disturbance to the natural beauty of the basin.

8. Agricultural water management projects reducing canal seepage would decrease canal bank growth and affect resident bird and small mammal populations.

9. Late season drawdown of the proposed reservoirs would expose inundated land and create an undesirable visual effect in the immediate area.

10. The Aztec Watershed project would clear 20 percent of the watershed of pinyon pine, juniper, and sagebrush native to the area. Clearing would create visual disturbance until the area is revegetated with range grasses.

11. The Mancos Valley project proposes to resection 16 miles and realign 12 miles of canal. The work would eliminate streambank vegetation and affect birds and small mammals using these areas.

Table IX-10 (contd)

BIOLOGICAL RESOURCES & SELECTED ECOSYSTEMS

1. Seven proposed multiple use reservoirs would provide a maximum of 42,000 acre-feet of additional habitat for fish, waterfowl, and shorebirds.

2. The installation of three projects would prevent future ditch blowouts and overtopping and would eliminate the inundation of wildlife cover and the possible loss of nesting habitat.

3. Construction site revegetation will provide wildlife cover and feed for songbirds, gamebirds, and small mammals.

4. The Summit Lake project would regulate spring runoff water and would convert an intermittent stream to a permanent stream and fishery.

5. Agricultural water management projects reducing canal seepage could decrease canal bank vegetation and resident songbird and small mammal populations.

6. Rangeland cleared in the Aztec Watershed would destroy valuable big game habitat. However, the clearing could have a beneficial effect by providing an ecotone. The ecotone would provide a mixture of vegetation from two plant communities.

7. Fluctuation of the surface level of the seven proposed reservoirs could affect the wildlife populations, especially fish. Precautions must be taken to assure a sufficient supply of water during critical periods.

8. Five proposed projects would replace 1,600 acres of pastureland, hayland, and brushland with row crops. The conversion would reduce the amount of bird and small and large mammal cover provided by the previous land users. The row crops would, however, provide an additional food source for resident wildlife.

9. The Mancos Valley project would realign 12 miles and resection 16 miles of ditch. The work would destroy bird and small mammal habitat by removing valuable vegetative cover.

10. The proposed reservoirs would increase human use of the adjacent areas and could disturb resident wildlife populations.

Table IX-10 (contd)

QUALITY CONSIDERATIONS OF WATER, LAND & AIR RESOURCES

1. Construction of multiple use reservoirs would help to reduce sediment loads in irrigation canals by increasing the storage capacity for spring runoff.

2. Proposed projects to reduce canal erosion would decrease sediment loads and increase the quality of water carried in the improved systems.

3. Revegetation of all construction sites will decrease the likelihood of erosion on these areas.

4. The elimination of canal bank slippage on the Park Ditch and the Morrison Consolidated Ditch would reduce sediment deposition in the ditch systems.

5. The Aztec Watershed project would reduce sediment erosion and floodwater damage to the town of Aztec, New Mexico. The project would also protect a county road during floods. Three class "C" structures are planned for construction.

6. Five projects would provide late season irrigation water. The improvements would regulate water delivery and reduce erosion damage in early spring due to high quantities and velocity of spring runoff.

7. The installation of three projects would prevent future ditch blowouts and overtopping, and would eliminate the inundation of croplands below the canals.

8. All agricultural related projects will include structures for improving irrigation water management.

9. The installation of seven reservoirs would provide a maximum of 42,000 acre-feet of aquatic habitat for fish, waterfowl, and shorebirds.

10. Irrigation system rehabilitation is estimated to reduce salt outflow by 181,000 tons and reduce salt withdrawals by 31,900 tons.

11. The proposed projects for the San Juan River Basin would serve 180,000 acres of irrigated land.

Table IX-10 (contd)

12. Five proposed projects would replace 1,600 acres of pasture, hayland, and brushland with row crops. The conversion would increase agricultural related pollution unless careful irrigation water management is practiced.

13. The use of proposed reservoirs by motor boats and recreationists could decrease the water quality in and below the impoundments with the introduction of petroleum pollutants.

14. All construction activity will temporarily reduce water, land, and air resources quality.

HISTORICAL, ARCHEOLOGICAL & GEOLOGICAL RESOURCES

1. The Aztec Watershed project would protect the historic town of Aztec, New Mexico from flood damage.

IRREVERSIBLE & IRRETRIEVABLE COMMITMENT*

1. Proposed reservoirs would inundate approximately 1,000 acres above the water retention structures.

2. Fill material for construction of the water retention structures will be permanently committed.

3. Projects realigning irrigation canals would withdraw land frm future agricultural or bird and small mammal use.

4. Concrete, steel, labor, and technical assistance for all proposed projects would be irretrievable.

*Assume proposed projects would remain serviceable after installation.

X. COORDINATION AND PROGRAMS FOR FURTHER DEVELOPMENT

Productive use and future development of the physical, biological, social, and economic resources of the basin are important responsibilites of local people. Wise and careful management can enhance and perpetuate the quality and usefulness of the environment, but many efforts including research, education, and land use planning are needed. There are many federal, state, community, and private programs available, that are applicable to specific segments of conservation planning and implementation. In many instances, there is duplication of effort, overlapping of purpose and scope, and agency rivalry in the application of these programs. Alternative levels of development exist not only in the physical and economic potentials but also in the choice of programs that will best solve the problems and satisfy the needs. To more effectively extend the services of available federal and state agency programs, USDA Committees for Rural Development have been formed. These committees assist rural communities groups, and individuals locate ans secure the needed service programs. Evaluation of alternative programs, when a choice is available, is up to the local people.

If land and water resource problems are recognized and advance planning is completed in time, the USDA will have the necessary programs available when farm operators need assistance in developing the new irrigated cropland projected for the basin. All of the existing programs (listed in a previous Chapter of this report) will be needed in developing the resources. One of the largest needs will be for a loan program to finance needed conservation practices, land development, and irrigation facilities for new and old irrigated areas. The Farmers Home Administration loan programs can do a part of this, but the ever expanding capital needs of agriculture create a need for new capital sources. The Soil Conservation Service, working through local soil conservation districts, will provide technical assistance in farm and ranch planning, soil surveys, structural program investigations, and for installing conservation practices. The Agricultural Stabilization and Conservation Service will need to provide an expanded program of cost sharing (through REAP) for conservation practices that are deemed to be of public benefit. The Cooperative Agricultural Extension Service through the local county agents, will need an expanded program of adult education and leadership training, particularly for the new operators who move into the basin and are unfamiliar with local farming methods and climatic problems.

Program coordination between all of the concerned federal, state and local agencies is necessary to assure that the proposed land and water resource development projects complement each other, and provide for a coordinated development of the resources and economy of the basin.

The opportunity for federal assistance to obtain greater returns from the resource base was presented in Chapter I, opportunities utilized. This may be partially due to (1) lack of knowledge or interest in the programs, and (2) fiscal or legislative limitations inherent in the existing programs. If resource utilization is to improve, the people will need to accept and support the concept of resource management. Initial acceptance must be with each individual; and ultimate support must be through group action, either by political subdivisions or private organizations. Group participation is essential for implementation by permitting democratic decision on those features of the improvement program that affect or serve more than the individual.

Information and education services offered by various state and federal agencies cover a rather broad spectrum of interests. They range from conservation practices through home economics to agricultural production economics. Regardless of area interest, they are aimed at improving the conditions existing in the basin's farm or in rural areas. Program and information services of various state and federal agencies should be improved and intensified in order to bring the conservation message to a greater number of people in a manner that provokes interest and stimulates activity.

An excellent example of this type activity is the nationally known *Smoky Bear Fire Prevention Campaign*. Professionally administered, this advertising program has probably done more to reduce the rate of wildfire damage than any other Forest Service program.

Another good example is the Soil Stewardship Program, sponsored by the National Association of Soil and Water Conservation Districts, which promotes responsible stewardship of the nation's soil and water resources through local church programs.

Eventually, the effective development and management of water and related land resources will require a consolidated approach through group planning and application of solutions. Existing laws, which permit cities, towns, and special benefit districts to enter the field of resource development and management, stress local initiation of their application. The implementation of the proposals of this report, which are designed to improve living conditions for the residents, rests solely with those residents. State and federal agencies can provide consultative and technical services, but these alone cannot and will not accomplish the efficient use of resources without community and group initiated action. Local individual leadership needs to be stimulated and their influence used to promote conservation.

County land and water regulatory organizations are needed. County Planning and Zoning Commissions established under law and working with state and federal agencies, could plan for efficient and optimum use of water and related land. These commissions should have the legal authority to negotiate land easements, contract for services, levy taxes, and make

zoning decisions to provide for the beneficial use of the resources while protecting public and private investment.

The U.S. Department of Housing and Urban Development currently sponsors a joint venture between the federal government and the private insurance industry whereby qualifying residential and business properties existing in flood hazard areas will be eligible for flood insurance at reduced rates. New properties would have to pay the unadjusted premiums. This program will be effective only if local or state organizations take the proper steps to provide zoning that will reduce or prevent future flood damages.

Land use planning expertise is needed to provide highway designers and urban developers with physical information which will enable them to provide adequate safeguards to the basin's fragile water and land resources. The Soil Conservation Service can provide soils data pertaining to the physical suitability of soils for road or house building, construction of sanitary disposal systems, drainage characteristics, and other information about the capabilities of the soils for nonagricultural use. Specific legislation or ordinances requiring soil suitability surveys to be made would insure more satisfactory developments.

Identification of these areas and the evolution of coordinated development plans, both within them and along their fringes, will insure against misuse and/or extensive and expensive rehabilitation by future generations.

In this age of natural landscape use and modification, the task is one of achieving balanced development between intrinsic and extrinsic values. The objective in rural areas should be the identification, preservation, and protection of the most outstanding natural values and insuring that man-made values, once introduced, are developed in harmony with the environment.